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ANCIENT EGYPTIAN MATERIALS & INDUSTRIES

ANCIENT EGYPTIAN MATERIALS & INDUSTRIES

BY

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'Is there any thing whereof it may be said, See, this is new? it hath been already of old time, which was before us.'

Ecclesiastes, i. 10.

PREFACE TO THE THIRD EDITION

As the result of recent excavation, research, analysis and publication since the last edition of this book appeared, so much fresh knowledge about ancient Egyptian materials and industries has become available that in order to bring the subject up to date a new edition is necessary.

The book has been largely re-written, re-arranged and much enlarged and three additional chapters have been added, on Adhesives, Beads and Inlaid Eyes respectively. Other new material deals especially with Dyeing, Glass, Glazed Ware, Mummification, Perfumes, Pottery, Stone Vessels, Sugar, Textile Fibres and Wood, but practically no section has been left without some addition and improvement. The Historical Summary and the Chemical Analyses also have been revised and amplified.

Although I have pointed out what I believe to be certain mistakes that occur in the literature of Egyptology and have expressed definite opinions on various disputed matters, I have endeavoured to bear in mind the precept of Robert Boyle[1] that 'a man may be a champion for truth without being an enemy to civility; and may confute an opinion without railing at them that hold it' and I would add in the words of Leeuwenhoek[2]: 'As I aim at nothing but Truth, and so far as in me lieth, to point out Mistakes that may have crept into certain Matters; I hope that in so doing those I chance to censure will not take it ill; and if they would expose any Errors in my own Discoveries, I'd esteem it a Service; all the more because 'twould thereby give me Encouragement towards Attaining of a nicer Accuracy.'

The friends who have helped me with information, suggestions and materials for analysis are too numerous to allow of their being mentioned separately by name, but to all of them I owe much, especially to Mr. Guy Brunton, O.B.E.

Cairo, 1945. A. Lucas.

[1] *The Sceptical Chymist*, 1661.
[2] A. van Leeuwenhoek, *Letters*, 1632–1723.

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ANCIENT EGYPTIAN MATERIALS & INDUSTRIES

ANCIENT EGYPTIAN MATERIALS & INDUSTRIES

INTRODUCTION

For the full understanding of ancient Egyptian materials and industries some slight knowledge at least of the history of the country is necessary in order that the great antiquity of the civilization and the remote dates at which many of the materials were used and many of the industries practised may be realized. A brief historical outline, therefore, will be given.

Fossil remains of primitive man have not been discovered so far in Egypt, the earliest evidence of human habitation of the Nile valley being certain stone weapons and implements (principally of flint) that have been found in large numbers in various parts of the country. With these their owners could hunt and fight, but that is all that is known about them, since neither their habitations nor their graves, if they had either, have been found. These shadowy Egyptians are called the Old-Stone Age (Paleolithic) people and they were simply hunters following the animals they lived on about the country, that is, they were food gatherers and not food producers and subsisted on the results of the chase and on the fruits, seeds, plants and roots they found growing wild. Immediately succeeding them came the New-Stone Age (Neolithic) Egyptians, who until recently were equally unsubstantial, but whose stone weapons and implements were of a more advanced type than those of their predecessors. Of these later people, settlements and cemeteries have now been discovered.[1, 2, 3] which prove that although they were still in the Stone Age, that is without any knowledge of the use of metals, they were no longer merely food gatherers, but food producers and that they practised agriculture; domesticated

[1] P. Bovier-Lapierre, *Une nouvelle station néolithique au nord d'Hélouan,* in *Compte rendu du Congrès international de géog.,* Le Caire, 1925, IV (1926), pp. 268–82.

[2] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*; G. Caton-Thompson, *The Royal Anthrop. Inst. Prehistoric Research Expedition to Kharga Oasis, Egypt,* in *Man,* XXXII (1932), 158.

[3] H. Junker, *Merimde-Benisalâme,* 1929, 1930.

animals; made pottery; wove fabrics; plaited baskets and mats; made bone, as well as stone, implements; made shell and stone beads and fashioned small vases out of such a very hard stone as basalt.[1, 2]

The Stone Age was followed by a period of unknown duration, at the commencement of which came the dawn of the knowledge of metals when copper and gold were employed occasionally for small articles of personal adornment and which ended with a greater use of gold, a slight use of lead and silver and a considerable use of copper for weapons, tools and household utensils. This period includes the Badarian civilization and the early, middle, and late Predynastic periods, during which time the country was split up into a number of petty states, from the chaos of which gradually emerged two kingdoms, one of the North or Lower Egypt (Delta) and the other of the South or Upper Egypt. Nothing certain is known about either the separate states or the two kingdoms, beyond the fact of their existence and that almost certainly the Delta was more advanced in civilization, and was wealthier, than Upper Egypt, and the practical commencement of Egyptian history dates from about 3400 B.C. when Menes from Thinis near Abydos, King of Upper Egypt, became King also of Lower Egypt and welded the country into the united kingdom of Egypt.[3]

The historical period is divided for the sake of convenience into thirty Dynasties, each of which corresponds to a different royal House, analogous to the divisions of English history into the Houses of Normandy, Plantagenet, Tudor, Stuart, Hanover, and so on.

So little is known about the first two Dynasties that frequently they are either classed as Protodynastic, or grouped with the late Predynastic period, the whole being called Archaic.

With the Third Dynasty began the Old Kingdom or Pyramid Age, as sometimes it is called, which lasted until the end of the Sixth Dynasty.

The period from the Seventh Dynasty to the Tenth Dynasty inclusive was one of internal conflict and is very obscure. This is known as the First Intermediate period.

The Eleventh and Twelfth Dynasties constitute the Middle Kingdom or Feudal Age, a time of great prosperity.

[1] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, p. 72.

[2] H. Junker, *op. cit.*, 1929, p. 223.

[3] There had probably been a previous union of the North and South brought about by a conquest of Upper Egypt by the Delta king, but this did not last (J. H. Breasted, *The Predynastic Union of Egypt*, in *Bull. de l'Inst. franç d'arch. orientale*, XXX (1931), pp. 709–24).

From the Thirteenth Dynasty to the Seventeenth Dynasty inclusive was a period of disorganization, about which present knowledge is very scanty, except that it included an interval of foreign domination under the Hyksos kings. This is the Second Intermediate period.

The Eighteenth Dynasty ushered in the New Kingdom or Empire, which lasted until the end of the Twentieth Dynasty, during which time Egypt conquered the countries now known as Palestine and Syria respectively and became a great power in western Asia.

In the Twenty-first Dynasty the Empire fell to pieces.

Of the next four Dynasties, the Twenty-second to the Twenty-fifth inclusive, very little is known, except that during part of the time the country was under the domination first of the Ethiopians and later of the Assyrians.

In the Twenty-sixth Dynasty there was a revival of independence and prosperity, which was followed by the Persian conquest, and the period from the Twenty-seventh Dynasty to the Thirtieth Dynasty inclusive was one of Persian domination, except for brief intervals when the Egyptians gained temporary independence.

After the conquest of the Persians by the Greeks, Alexander the Great took possession of Egypt and the Greek domination under his successors, the Ptolemies, lasted until Egypt became a Roman province, the country then remaining in Roman occupation until the Arab conquest.

As may be seen from the above short summary, there are several periods of Egyptian history, lasting in some cases two or three hundred years, about which very little is known, and even of the periods that are better known the information is very partial. With such gaps in the existing knowledge a final statement regarding the earliest or latest production or use of any material is impossible, and all that can be done is to give the dates for which the various materials have been recorded.

CHRONOLOGICAL SUMMARY*

Period	*Dynasty*	*Approximate Date*
Stone Age	Paleolithic Period	Undated
	Neolithic Period	Possibly ended about 5000 B.C.
Predynastic	Badarian Civilization	5000 to 3400 B.C.
	Early Predynastic	
	Middle Predynastic	
	Late Predynastic	
Protodynastic	I and II	3400 to 2980 B.C.
Old Kingdom	III	2980 to 2900 B.C.
	IV	2900 to 2750 B.C.
	V and VI	2750 to 2475 B.C.
First Intermediate Period	VII to X	2475 to 2160 B.C.
Middle Kingdom	XI and XII	2160 to 1788 B.C.
Second Intermediate Period[1]	XIII to XVII	1788 to 1580 B.C.
New Kingdom or Empire	XVIII	1580 to 1350 B.C.
	XIX	1350 to 1200 B.C.
	XX	1200 to 1090 B.C.
Period of which little is known[2]	XXI to XXV	1090 to 663 B.C.
Late Egyptian Period	XXVI	663 to 525 B.C.
Persian[3]	XXVII to XXX	525 to 332 B.C.
Greek (Ptolemaic)	—	332 to 30 B.C.
Roman[4]	—	30 B.C. to A.D. 640
Arab	—	A.D. 640

[1] Includes the period of Hyksos domination.

[2] Includes a lengthy period of Ethiopian rule and a short period of Assyrian domination.

[3] Includes a brief period of Egyptian rule in the Thirtieth Dynasty.

[4] Includes the Byzantine period.

* The system of dating adopted is that of Professor J. H. Breasted.

CHAPTER I

ADHESIVES

The principal adhesives employed, or possibly employed, as cementing materials in ancient Egypt, arranged in alphabetical order for the sake of convenience, were albumin (white of egg); beeswax; clay; glue; gum; gypsum (plaster of Paris); natron; resin; salt; solder and starch, which may now be considered.

Albumin

Albumins are natural nitrogenous bodies of complex composition, containing sulphur in small proportion, that occur both in animals and in plants, the only albumin, however, that need be considered here being egg albumin, or white of egg. This has often been suggested as the adhesive that was employed for the ancient Egyptian paint, thus Spurrell states[1] that he found proof of the use of egg albumin on the Twelfth Dynasty tomb paintings at Kahun. The evidence he gives was that the paint was unaffected both by hot and by cold water and also by soap; that when heated it charred and gave off ammonia; that it was insoluble in dilute hydrochloric acid, but soluble in the strong acid, as the result of which he says 'There can be little doubt that it is albumen. It cannot be gelatine or any resinous gum.' He also says that 'A peculiar condition, somewhat glossy, of the surface of the stone around other paintings was found to be caused by a dressing of this albumen over surfaces now devoid of colour,' which he suggests may have been done to fill up the pores of the stone. He states that 'There appears to be no doubt left that all the colours which I have examined having the above characters had egg albumen for a medium and this extends from Senefru's time to that of the Romans . . .' Spurrell also reports egg albumin from some of the Eighteenth Dynasty paintings at El Amarna.

[1] F. C. J. Spurrell, Notes on Egyptian Colours, *The Archaeological Journal*, LII, Second Series, Vol. II (1895), pp. 222–39.

Laurie obtained a positive reaction for both nitrogen and sulphur when testing the adhesive used to fasten ancient Egyptian gold leaf to plaster (gesso), and, therefore, concluded that the adhesive employed was egg albumin.[1]

Ritchie also tested the adhesive used for fixing gold leaf on plaster (gesso) and found that when examined spectroscopically there was evidence of the presence of phosphorus, which he suggested possibly might indicate egg albumin.[2]

While in no way denying that egg albumin may have been employed sometimes in ancient Egypt as an adhesive, I would point out that, although this has been shown to be probable, it has not been proved. There are considerable difficulties in identifying albumin with certainty in very small specimens of material that have been exposed for hundreds, or even thousands, of years, particularly as there is no specific test for albumin, but also because albumin, even if originally present, may have undergone considerable chemical change. The fact that Spurrell found the material he tested was nitrogenous organic matter is no proof that it was albumin, since glue is also a nitrogenous organic matter that might well have been present. Also, if the stone on which the painting was done had been sized with albumin, as Spurrell suggested, the albumin found may have been present in the size and not in the paint. I have examined a very large number of specimens of ancient Egyptian paint and have always found it to be so very easily removed by water that I cannot think the adhesive was albumin, unless, if originally present, it has perished. Further, although the particular specimens of paint referred to by Spurrell, that were not acted on by water, may have contained albumin, it should not be forgotten that beeswax and resin, both of which were certainly sometimes used during the Eighteenth Dynasty for covering tomb paintings, would also have been unacted upon by water.

With reference to Laurie's work, here again the nitrogenous organic matter found may have been glue and not albumin, and the sulphur may have been derived from glue, which also contains it,[3] and not from albumin.

[1] A. P. Laurie, (*a*) Methods of Testing Minute Quantities of Material from Pictures and Works of Art, *Analyst*, 58 (1933), p. 468; (*b*) Sir R. Mond and O. H. Myers, *The Bucheum*, pp. 68–9.

[2] Private letter, the specimens tested having been supplied by me.

[3] Sulphur in modern glue may be due to the use of sulphurous acid for bleaching, but this is not the case with the ancient glue.

Ritchie, while suggesting that the presence of phosphorus possibly might indicate albumin, lays no stress on this. The phosphorus, however, might well have been in the form of calcium phosphate, which is not an uncommon constituent of limestone, and, therefore, of the whiting of which the gesso tested was composed.

In my opinion, much more work is required before it can be accepted as satisfactorily proved that the ancient Egyptians employed egg albumin as an adhesive, and the criticisms made are intended to be helpful and not merely destructive. Although the domestic fowl was not introduced into Egypt until a late period, egg albumin was plentiful and easily obtainable, as geese and ducks were abundant. The origin of the present-day barnyard fowl was the Indian jungle fowl (Gallus banciva).[1]

Beeswax

One adhesive used in ancient Egypt for painting and for coating paintings, about which there is no uncertainty, is beeswax, but as these uses are not as an adhesive in the ordinary sense, they will be considered in connexion with painting materials.[2] Other uses of beeswax, also not as an adhesive, were in mummification[3]; for shipbuilding[4]; for making magical figures[5]; for bronze casting[6]; and, at a very late date, for covering the surface of writing tablets[7]; all of which will be dealt with in other connexions. Here the enquiry will be limited to the use of beeswax as an ordinary adhesive only, for which purpose it was employed in considerable amount. Thus it was used for luting on the lids of vases, five of which of alabaster so treated were found in the tomb of Tut-ankhamun,[8] and it was also present on several alabaster lids from the same tomb,[8] the vases of which were missing; it was used, too, for fixing at least three alabaster vases to their pedestals[8] and at the back of two uraei,[8] manifestly as an adhesive. Spurrell found beeswax employed for fastening in place the flint teeth of an Eighteenth Dynasty sickle[9] and Winlock gives an example of its use with limestone powder in the Middle Kingdom for cementing on a razor handle.[10] Another

[1] Howard Carter, An Ostracon depicting a Red Jungle-Fowl, *Journal of Egyptian Archaeology*, 9 (1923), pp. 1–4.
[2] See pp. 401–2. [3] See p. 347.
[4] M. Rostovtzeff, *A Large Estate in the Third Century, B.C.*, p. 123.
[5] See p. 390. [6] See p. 254. [7] See p. 416. [8] Analysed by me.
[9] F. C. J. Spurrell, *Tell el Amarna*, W. M. F. Petrie, pp. 37–8.
[10] H. E. Winlock, *The Treasure of El Lahun*, pp. 63, 74.

use of beeswax was for curling and plaiting wigs, which will be described in connexion with hair.[1]

It does not seem to have been the custom to place beeswax in tombs and no record of the finding of it can be traced, but at El Amarna a piece of beeswax was found in a house.[2]

Clay

The use of clay as mortar with sun-dried bricks will be dealt with in connexion with building materials.[3]

Glue

This material is one of the earliest, best known and most reliable of adhesives, especially for wood. It is made by extracting certain animal products containing gelatine, such as bones, skins, cartilage and tendons, with boiling water, concentrating the liquid by evaporation and then pouring it into moulds, in which, when cold, it sets into a solid mass.

Glue was used in ancient Egypt for many different purposes, namely, (*a*) to fasten wood together and to fix ebony and ivory inlay in place; (*b*) for mixing with whiting to make both plaster and 'stopping'; (*c*) probably to fasten coarse woven linen fabric to wood and to plaster and to fasten gold foil to plaster; (*d*) probably as a sizing material for stone and plaster surfaces before painting; and (*e*) possibly as an adhesive for pigments. These various uses may now be considered.

At what date and for what purpose glue was first employed in Egypt is uncertain, but probably not as an adhesive for wood, since in the Fourth Dynasty tomb of Hetepheres the wood was fastened together by means of mortise and tenon joints and then sometimes bound with strips of hide,[4] which suggests that glue was not used, though as practically all the wood had perished, this could neither be proved nor disproved. Several specimens of plaster from this tomb, however, analysed by me consisted of whiting containing nitrogenous organic matter that might have been glue, since so far as could be determined

[1] See p. 42.

[2] T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 25.

[3] See p. 94.

[4] G. A. Reisner, *Bull. Mus. of Fine Arts, Boston*, XXV (1927), Supplement; XXVI (1928), No. 157; XXX (1932), No. 180.

from the small amount of material available for analysis, there was not any other adhesive present, and some adhesive is essential, whiting possessing practically no natural coherence.

Plaster of this nature (i.e. whiting and glue, which is termed 'gesso' by Egyptologists) has been identified by me from the Third Dynasty, where it was used for fastening the small blue faience tiles to the walls in the step pyramid at Saqqara and in the great tomb of Zoser adjoining the pyramid, and also from the Fifth Dynasty, where a carved limestone bust was covered with a painted layer of this plaster. Gesso was employed on a large scale during the Eighteenth Dynasty and onwards for applying to wood as a ground for painting and gilding, being often worked with designs in low relief before being gilt, and at a later date it was used extensively for making cartonnage mummy masks and coffins, which consist of layers of linen and gesso, or, at a still later date, of old papyrus documents and gesso, with or without linen. Where gesso was on wood, there was sometimes a layer of coarse woven fabric (linen) between the two, and, not only was the canvas probably treated with glue to make it adhere to the wood on one side and to the plaster on the other, but in those instances in which the gold was thick, this was probably also fastened on with glue,[1] though whether glue was used when the gold was only thin leaf has not been determined.

A specimen of glue of Eighteenth Dynasty date was found by Howard Carter in a rock chamber over the mortuary temple of Hatshepsut at Deir el Bahari. This, which was examined by me, was in the form of a rectangular piece thirteen centimetres long with a square section of about two centimetres each way, that manifestly had been cast, and, except that it had dried and shrunk, it could not be distinguished from modern glue, to all the usual tests for which it responded.[2]

The use of glue probably is shown in a scene on a tomb wall of Eighteenth Dynasty date at Thebes,[3] and also on an ostracon now at Leipzig, of which the date is not given.[4]

Spurrell reports[5] gelatine used as an adhesive in paint from the

[1] Very thick foil was fastened on with gold rivets.

[2] A. Lucas, Appendix II, pp. 166–7, *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

[3] P. E. Newberry, *The Life of Rekhmara*, Pl. XVII.

[4] N. de G. Davies, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1916–1919*, p. 32, Fig. 22.

[5] F. C. J. Spurrell, *Medum*, W. M. F. Petrie, p. 50.

Fourth Dynasty, and Toch thought he found evidence of glue or gelatine on the mural paintings in the Fifth Dynasty tomb of Perneb.[1] I have examined a large number of pigments from ancient Egyptian painted objects, including mural paintings, but the specimens of material available have all been too small for any satisfactory determination of the nature of the adhesive to be made, particularly as there is no specific test for glue. Also, it should not be forgotten that the presence of glue in a paint does not necessarily mean that it was employed as a binder, since it may have been used in the same manner as modern size, namely, to fill up the pores in the plaster, stone, or other painting ground, before the paint was applied.

Brunton mentions a small painted wooden box of Fifth Dynasty date with mitred joints fastened with some 'resinous material, which was possibly glue.'[2] Mace and Winlock state[3] that a staff from a Twelfth Dynasty tomb was joined with glue, and Carter found glue used as an adhesive on a toilet box and on a game board, both of late Middle Kingdom, or Second Intermediate Period date.[4] Winlock says[5] that glue was used on two of the coffins of Queen Meryet-Amun of the Eighteenth Dynasty, and that a wooden box from the same tomb was 'carelessly mended with a mixture of mud and glue.'[6] Glue is present on many of the objects from the tomb of Tut-ankhamun, where it was employed exactly in the manner of the modern joiner to fasten wood together and to fix ebony and ivory veneer and inlay in place. A number of specimens of 'stopping' from the same tomb, used to fill holes and to cover up imperfections in wood, were found on analysis by me to consist of a mixture of whiting and glue (i.e. gesso), coloured (in one case with yellow ochre) to match the colour of the wood, or of the paint on the wood.[7] Several hundred tiny *shawabti* figures of uncertain, but late, date, in the Cairo Museum, I examined were found to be composed of powdered limestone held together with glue and moulded.[8]

[1] M. Toch, The Pigments from the Tomb of Perneb, *Journal of Industrial and Engineering Chemistry*, 1918, p. 118.

[2] G. Brunton, *Mostagedda*, p. 98.

[3] A. C. Mace and H. E. Winlock, *The Tomb of Senebtisi at Thebes*, p. 89.

[4] The Earl of Carnarvon and H. Carter, *Five Years' Explorations at Thebes*, pp. 56–7.

[5] H. E. Winlock, *The Tomb of Meryet-Amun at Thebes*, pp. 16, 18, 21.

[6] H. E. Winlock, *op. cit.*, p. 44.

[7] A. Lucas, *op. cit.*, pp. 166–7.

[8] Nos. J.66773–66774.

GUM

Gum is obtained at the present day largely from various species of acacia that grow in the Sudan, but as the acacia also grows in Egypt, where it was more plentiful formerly than now, the greater part, if not the whole, of the ancient Egyptian gum may have been obtained locally. Pliny states[1] that in his day the best gum was obtained from Egypt, which, however, may mean from the Sudan through Egypt.

The 'gum of myrrh' mentioned in the ancient records[2] was not gum in the ordinary sense, but an odoriferous gum-resin used as incense, and the 'gum of god's land'[3]; the 'gum of Punt'[4]; the 'gum' from Genebtyew[5] and the 'gums'[6] were probably similar material, and not gums, since, even in modern commercial practice, many gum-resins are loosely called gum.

According to Herodotus,[7] gum was employed to fasten together the linen bandages in which mummies were wrapped after embalming, with reference to which he states that the Egyptians mostly used it instead of glue. Gum has been identified on mummy bandages in two instances (undated) by Reutter,[8, 9] and in four instances (all Twentieth Dynasty) by me, and Elliott Smith states[10] that 'a sheet of cloth saturated with some gum-like substance was placed in front of the face' of the mummy of Amenophis III (Eighteenth Dynasty), and he also mentions 'gum-saturated bandages.'

Spurrell found gum, which he states was gum acacia, used as an adhesive for paint in the Eighteenth Dynasty.[11] This he says had decayed and left the pigment pulverulent and loose. He also states[11] that 'Several pots of paint were found to have a thick layer of gum overlying the colour, which had settled out at the bottom, these had not been exposed and the gum answered all the usual tests. Gum was also used for the painting of Akhenaten and the little princesses. It was used also on parts of the painted pavement.' Laurie found gum in a

[1] *Natural History*, XVI: 21.
[2] J. H. Breasted, *Ancient Records of Egypt*, II, 288; III, 116.
[3] J. H. Breasted, *op. cit.*, IV, 29. [4] J. H. Breasted, *op. cit.*, IV, 29, 31.
[5] J. H. Breasted, *op. cit.*, II, 474. [6] J. H. Breasted, *op. cit.*, IV, 378.
[7] II: 86. [8] L. Reutter, *De l'embaumement avant et après Jésus-Christ*, pp. 52, 96. [9] L. Reutter, *Sphinx*, XVII (1913), p. 113.
[10] G. Elliott Smith, *The Royal Mummies*, p. 48.
[11] F. C. J. Spurrell, *The Archaeological Journal*, LII, Second Series, Vol. II (1895), pp. 222–40.

paint of Nineteenth Dynasty date.[1] Another probable use of gum was for binding together the powdered pigments to make the cakes that are found on the scribes' palettes.

Gypsum

The earliest use of gypsum (plaster of Paris) as an adhesive, so far as is at present known, was for repairing a large pottery vessel of predynastic date found by Professors Menghin and Amer at Ma'adi, and among the objects from the tomb of Tut-ankhamun was a pottery jar, the cover of which was fastened on with gypsum, the material in both cases having been analysed by me.

The most important use of gypsum as an adhesive in ancient Egypt was for mortar, and another important use, though not exactly as an adhesive, was for plaster, both of which will be dealt with in connexion with building materials.[2]

For whatever purpose gypsum is employed it must first be calcined, as it is only after calcination and subsequent slaking with water that its adhesive property is developed.

Natron

The use of natron as an adhesive will be described in connexion with the making of faience.[3]

Resin

Another important adhesive employed in ancient Egypt was resin, the use of which goes back to the neolithic period, when it was employed to fix in place the flint teeth of a sickle,[4] from which time onwards it was in regular use. Thus a narrow-necked jar from the First Dynasty tomb of Hemaka was sealed with a mixture of resin and quartz sand;[5] a cement of resin and powdered limestone was found attached to some diorite paving blocks and also to some tesserae of Third Dynasty date from Saqqara;[6] a mixture of resin and broken

[1] A. P. Laurie, (a) *The Materials of the Painter's Craft*, p. 22; (b) *The Painter's Methods and Materials*, pp. 17, 172. [2] See pp. 93–8. [3] See pp. 185, 201.
[4] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, p. 45.
[5] Analysed by me.
[6] C. M. Firth and J. E. Quibell, *The Step Pyramid*, p. 127. Analysed by me.

alabaster (both coarse fragments and fine dust) was used as an adhesive on a Third Dynasty sarcophagus from Saqqara;[1] resin was used for securing in place the metal bolts of the granite sarcophagus of Chephren (Fourth Dynasty);[2] a mixture of resin and powdered limestone fastened on the handle of a Middle Kingdom razor,[3] and incidentally it may be mentioned that resin is the principal ingredient of many of the cements employed at the present day to fasten on the handles of knives and forks. The use of resin as an adhesive was well exemplified in the Eighteenth Dynasty tomb of Tut-ankhamun,[4] where it was employed to repair the broken lid of the sarcophagus;[5] on the rebated edge of the gold coffin, where apparently it was used to lute on the lid and so to make a tight joint; to lute on the lids of alabaster and limestone vases;[6] to fix an alabaster vase to its stand;[6] to cement in place spouts of some of the faience libation vases,[6] and to fasten inlay of stone, glass and faience into their setting.[6] Occasionally the resin was used alone, but more generally it was mixed with powdered limestone. A similar mixture was also employed for an ancient repair to the alabaster canopic box of Horemheb (Nineteenth Dynasty) now in the Cairo Museum.[6] Resin was also used on a Twenty-sixth Dynasty sarcophagus from Saqqara to support the lid just before it settled into position,[7] and it was present between the lid and the top of the box of a coffin which I examined, but particulars of which now cannot be traced.[7]

When resin, or a resin mixture, was employed in ancient Egypt to fix inlay in place, the effect was often enhanced by the cement being tinted the same colour as the inlay, blue cement being used for blue inlay and red cement for red inlay and so on. Inlay of transparent quartz, or of transparent calcite, was fastened in place with a red cement, which improved the appearance of the stone considerably, imparting to it the semblance of carnelian. Resin was used occasionally as a mortar in building.[8]

A further use of resin; of resin and powdered limestone and of resin

[1] Submitted by M. J-P. Lauer and analysed by me.

[2] W. M. F. Petrie, *The Pyramids and Temples of Gizeh*, p. 108.

[3] H. E. Winlock, *The Treasure of Lahun*, pp. 63, 74.

[4] A. Lucas, Appendix II, p. 167, *The Tomb of Tut-ankh-Amen*, II, H. Carter.

[5] This was originally reported by me to consist of gypsum, but the specimen was not taken by me and there must have been some mistake, since a subsequent sample taken by myself was found to consist of a mixture of resin and powdered limestone.

[6] Analysed by me.

[7] Submitted by Mr. C. M. Firth and analysed by me.

[8] See p. 94.

and broken quartz, though not as an adhesive, will be described in connexion with mummification.[1]

Solder

Solder is a cementing material used for joining metals, and consists of any metal, or alloy, having a melting point lower than that of the metal, or metals, joined. Examples of the ancient use of solder will be given when dealing with metals.[2]

Starch

Pliny states[3] that starch made from the finest wheaten flour, mixed with boiling water, was used in connexion with the manufacture of papyrus, but no adhesive except its own juice was necessary to make small sheets of papyrus, if this were used freshly gathered,[4] but since an adhesive was required to fasten the small sheets together to make a roll, the starch was probably for this latter purpose. No identification of starch on papyrus, or on other ancient Egyptian material, can be traced.

Salt

The use of salt as an adhesive will be dealt with in connexion with the making of faience.[5]

Unidentified Adhesives

There are certain early cementing materials that have not yet been sufficiently investigated and their nature is still unknown. Thus, the cement used for fixing in place the sickle flints and arrow heads from the First Dynasty tomb of Hemaka at Saqqara has not yet been identified. In each case the cement contains a very large proportion of calcium carbonate (44 per cent in one specimen), and also organic matter, the nature of which, however, it was impossible to determine with the small amount of material available for analysis. Also, some of the plaster and mortar from the Third, Fourth and Eighteenth Dynasties respectively[6] consists essentially of calcium carbonate and

[1] See pp. 365, 375. [2] See p. 248. [3] *Natural History*, XIII: 26.
[4] See p. 164. [5] See p. 206. [6] See p. 96.

contains no adhesive that can be recognized, though, in some cases, there is a very small proportion of clay, organic matter, or gypsum respectively present. The latter (gypsum), however, is probably not the adhesive, as there is not any evidence that the material has been calcined, and gypsum is inert unless so treated.[1] This problem has been discussed by Dr. J. W. Matthews and by Professors Bramwell and Briscoe,[2] who suggest that a slight degree of adhesion might have been obtained by the solution, on the addition of water, of the calcite present, and its subsequent re-crystallization on drying, or by 'hydraulicking,' by which is meant the feeble calcination of a material that contains a small proportion of clay. In the case of plaster, it should not be forgotten that the groundwork (clay or porous limestone) to which the plaster is applied may itself form the adhesive, if the layer of plaster is only thin. Although practically almost any material, even totally inert quartz, will cohere to at least a small extent if sufficiently finely ground and moistened, it will fall apart again on drying; hence fine grinding is not the solution of the problem, and, moreover, the material is not finely ground.

[1] See p. 98.

[2] Sir R. Mond and O. H. Myers, *Cemeteries of Armant*, I, pp. 122–30.

CHAPTER II

ALCOHOLIC BEVERAGES AND SUGAR

The alcoholic beverages of ancient Egypt were of two kinds, namely, beer and wine.

Beer

For an understanding of the nature and mode of preparation of ancient Egyptian beer, some knowledge of the underlying principles of brewing is necessary and, therefore, modern beer and its manufacture will be described very briefly.

Modern beer is essentially an infusion of malt, flavoured with the bitter of hops and fermented with yeast: it contains usually from about 2 to about 6 per cent of alcohol by volume.

When barley, or other farinaceous grain, germinates, an active nitrogen-containing substance termed an enzyme (of which there are many kinds, the particular one now referred to being known as diastase), which is present naturally in the grain in small proportion, increases considerably in amount and converts a small part of the starch of the grain into a particular kind of sugar called maltose and a gummy material termed dextrin, the former of which becomes the food supply for the growing plant in its early stages. Malting is the reproduction of this natural process under conditions that can be controlled, the grain being first exposed to moisture and warmth until it germinates and then being heated to arrest further growth, in order that the sugar (maltose) formed may be conserved: the resulting product is termed 'malt.'

After malting comes brewing, in which there are three main processes, namely, (*a*) maceration of crushed malted grain, or of a mixture of malted and unmalted grain, in hot water, during which the diastase present converts that part of the starch of the grain, not previously acted upon, into maltose and dextrin; (*b*) boiling the solution extracted from the grain with hops, so as to flavour it, and (*c*) fermentation of the solution with yeast, which first of all, by means of an enzyme termed maltase, converts the maltose into another kind of sugar called

dextrose (maltose not being directly fermentable by yeast), which is then split up by still another enzyme (zymase) into alcohol and carbon dioxide gas, the alcohol and part of the gas remaining dissolved in the liquid. The essentials of brewing, therefore, are the conversion of the starch of a cereal grain into sugar and the subsequent change of this sugar into alcohol and carbon dioxide.

As a further preliminary to the description of ancient Egyptian beer, a beer called *bouza* made at the present day in Egypt by Nubians may be described. I examined sixteen different specimens of this *bouza*, purchased from retail dealers in Cairo: they were all similar and had the appearance of thin gruel: they contained much yeast, were in a state of active fermentation and had been made from coarsely ground wheat: the amount of alcohol present varied from 6.2 per cent to 8.1 per cent by volume, with a mean of 7.1 per cent.

Inquiries elicited the information that in Cairo *bouza* is prepared as follows, though doubtless there are variants of the method:

1. A good quality of wheat is taken; the dirt and foreign material are picked out and the wheat is ground coarsely.

2. Three-quarters of the ground wheat are put into a large wooden basin or trough and kneaded with water into a dough, yeast being added.

3. The dough is made into thick loaves, which are baked, though only lightly, so as not to destroy the enzymes or to kill the yeast.[1]

4. The remaining quarter of the wheat is moistened with water and exposed to the air for some time, after which, while still moist, it is crushed.

5. The loaves are broken up and put into a vessel with water and the crushed moist wheat added: the mixture ferments on account of the yeast present in the bread, though in order to induce a quicker fermentation a little old *bouza* from a previous brewing often is added.

6. After fermentation, the mixture is passed through a hair sieve, the solid material being pressed well on the sieve with the hands.

Operation No. 4 is manifestly a primitive and very incomplete form of malting, resembling very closely that described by Zosimos.[2] Malting, however, although general at the present day, is not essential, and at one time it was customary in certain parts of Europe to make beer from unmalted rye. But, as starch is not directly fermentable by yeast and requires to be converted into sugar before fermentation can take

[1] Specimens of this beer-bread were obtained and examined.

[2] See p. 20.

place (which is usually brought about by the diastase produced during malting), the fermentation of unmalted grain needs explanation. The same problem presents itself in the fermentation that produces the carbon dioxide to which the rising of leavened bread is due. The explanation is simple. Cereal grains contain a small amount of certain sugars (sucrose and raffinose), which, though not directly fermentable, are converted by one of the enzymes of the yeast (invertase) into dextrose, which, as already explained, is fermentable. In addition, however, there is also a small amount of diastase in the grain, which produces maltose from some of the starch present, this maltose subsequently being converted into dextrose, which undergoes fermentation. Sugars also may be formed from the starch of the grain by means of moulds, which are present on the grain and in the air and of which many 'contain . . . diastase in considerable quantity and are consequently possessed of powerful starch-converting activity,'[1] and moulds have been utilized in the East from very early times for the conversion of starch into sugar and of sugar into alcohol[2] and certain moulds[3] are used for saccharification purposes to-day on a very large scale in special methods of preparing alcohol.[4]

Lane in 1860 stated[5] that *bouza* 'which is an intoxicating liquor made from barley-bread, crumbled, mixed with water, strained and left to ferment, is commonly drunk by the boatmen of the Nile and by other persons of the lower orders.'

Burckhardt, writing in 1822, states[6] that in Berber (Nubia) *bouza* was made from strongly leavened millet bread, which was broken into crumbs, mixed with water and kept for several hours over a slow fire, after which more water was added and the mixture left for two nights to ferment: he describes the ordinary *bouza* as not being strained and looking more like soup or porridge than a beverage, but mentions a

[1] A. Chaston Chapman, *Micro-organisms and some of their Industrial Uses, Royal Society of Arts*, 1921, pp. 8–9.

[2] In Japan cultures of *Aspergillus oryzae* supply the diastase for the saccharification of the starch of rice and wheat bran used for making alcoholic drinks and in China a mixture of micro-organisms, of which the predominating one is a fungus (*Amyloces rouxii*) belonging to the group of mucors, is employed, not only for the saccharification of starch, but also for the fermentation of the sugar into alcohol (W. L. Owen, *Production of Industrial Alcohol from Grain by Amylo Process*, in *Industrial and Engineering Chemistry*, 25 (1933), pp. 87–9.

[3] *Amyloces rouxii* and certain special mucors such as *Rhizopus delemar*.

[4] The Amylo and Boulad Processes.

[5] E. W. Lane, *The Manners and Customs of the Modern Egyptians*, pp. 96, 342. (Everyman's Library.)

[6] J. L. Burckhardt, *Travels in Nubia*, 1819, pp. 143, 218.

better quality obtained by straining through a cloth: he also says that barley was used sometimes instead of millet and that it produced a superior beer, which was of a pale muddy colour and very nutritious: he says further that in Cairo and in all the towns and larger villages of Upper Egypt there were shops for the sale of *bouza* kept exclusively by Nubians, which is still true to-day.

Bruce in 1805 gave a similar account of the preparation of *bouza* in Abyssinia.[1]

A similar beer called *merissa* is brewed in the Sudan[2]: 'wherever the dura crop is found . . . there also is merissa made.'[3] A primitive method of malting is performed by the women, who chew the grain and then spit it out and use it.

Beer is mentioned frequently in the ancient Egyptian records[4, 5] as a divine offering, as an oblation, as a mortuary offering and as a beverage, the earliest reference known to me being one of the Third Dynasty, where a brewery carried on by women is mentioned[6]: the next reference in chronological order that can be traced is from the Fifth Dynasty, where beer is named as a mortuary offering.[7] Residues, however, of the predynastic period have been found in jars which originally contained beer that has evaporated.[8] Beer, therefore, manifestly is of very early date.

Beer, as well as having been made in the country, was imported also, though probably only to a small extent and at a comparatively late period, the only references to this that can be found being of New Kingdom date, where beer from Kedi in Asia is referred to.[9]

Egyptian beer is described by several of the classical writers; thus Herodotus says[10] that the Egyptians 'use a drink made of barley'; Diodorus states[11] that they 'make a drink of barley . . . for smell and sweetness of taste not much inferior to wine'; Strabo says[12] that 'Barley beer is a preparation peculiar to the Egyptians. It is common among many tribes, but the mode of preparing it differs in each' and that it was one of the principal beverages of Alexandria[13]; this same

[1] J. Bruce, *Travels to Discover the Source of the Nile*, VII (1805), pp. 65–6, 335.
[2] J. Petherick, *Egypt, the Sudan and Central Africa*, 1861, pp. 157–9: A. J. Arkell, Darfur Pottery, in *Sudan Notes and Records*, XXII (1939), n.s., pp. 83–4.
[3] C. B. Tracey, *Sudan Notes and Records*, VIII (1925), pp. 212–5.
[4] J. H. Breasted, *Ancient Records of Egypt*, V (Index), p. 108.
[5] A. Erman, *The Literature of the Ancient Egyptians*, trans. A. Blackman.
[6] W. M. F. Petrie, *Supplies and Defence*, in *Ancient Egypt*, 1926, p. 16.
[7] J. H. Breasted, *op. cit.*, I, 252.
[8] W. M. F. Petrie, *Prehistoric Egypt*, p. 43.
[9] A. Erman, *op. cit.*, pp. 207, 210. [10] II: 77. [11] I: 3.
[12] *Geography*, XVII: 2, 5. [13] XVII: 1, 14.

writer also states[1] that the Ethiopians made a drink both from millet and from barley; Pliny says[2] that an intoxicating beverage was made in Egypt from corn; Athenaeus states[3] that the Egyptians, who could not afford wine, used an intoxicating drink made from barley. During the Ptolemaic period brewing was controlled by the State.

The brewing of beer is depicted on a number of tomb walls, for example, in a Fifth Dynasty tomb at Saqqara[4]; in a Sixth Dynasty tomb at Deir el Gebrawi[5]; in a Middle Kingdom tomb at Meir[6]; in a Middle Kingdom tomb[7] and in an Eighteenth[8] Dynasty tomb respectively in the Theban necropolis, in each case bread-making and brewing being associated, the former being a preliminary step towards the latter.[9] The explanation of these tomb scenes seems to have been first pointed out by Borchardt.[10] Brewing also is illustrated by various tomb models, thus an Eleventh Dynasty wooden model found at Deir el Bahari shows the operations of corn being ground; dough being kneaded; the ' mash ' being made; the solution being fermented and the finished beer being poured into jars.[11] Similar models of about the same date are described by Garstang.[12] It is practically certain, therefore, that both in mode of preparation and in composition the ancient Egyptian beer approximated closely to the modern Nubian *bouza*.

According to a description attributed to Zosimos of Panopolis in Upper Egypt, who lived about the end of the third century or the beginning of the fourth century A.D., and spent his youth at Alexandria, ancient Egyptian beer was made as follows[13] : ' Take well-selected fine

[1] XVII : 2, 2. [2] *Natural History*, XIV : 29. [3] *The Deipnosophists*, I : 34; X : 418.
[4] G. Steindorff, *Das Grab des Ti*, Pls. 83–4.
[5] N. de G. Davies, *The Rock Tombs of Deir el Gebrawi*, II, p. 26, Pl. XX.
[6] A. M. Blackman, *The Rock Tombs of Meir*, IV, p. 35, Pl. XIII.
[7] N. de G. Davies and A. H. Gardiner, *The Tomb of Antefoker and his Wife Senet*, p. 15, Pls. XI, XIA.
[8] N. de G. Davies, *The Tomb of Ken-Amun at Thebes*, p. 51, Pl. LVIII.
[9] See also (*a*) H. F. Lutz, *Viticulture and Brewing in the Ancient Orient*, and (*b*) P. Montet, *La Bière*, in *Les scènes de la vie privée dans les tombeaux égyptiens de l'Ancien Empire*, pp. 242–54.
[10] L. Borchardt, *Zeit. f. äg. Sprache*, XXXV (1897), pp. 128–31.
[11] H. E. Winlock, *Egypt. Exped., 1918–20, Bull. Met. Mus. of Art, New York*, II (1920), p. 26, Fig. 12.
[12] J. Garstang, *The Burial Customs of Ancient Egypt*, pp. 63, 73–6, 86, 94, 126–8; Figs. 50, 61, 62, 75, 84, 124–5.
[13] The translation is that of C. G. Gruner, as given by Arnold (J. P. Arnold, *Origin and History of Beer and Brewing*, 1911). Other translations differ somewhat, for example those of H. F. Lutz (*Viticulture and Brewing in the Ancient Orient*, 1922, p. 78) and of P. Montet (*Les scènes de la vie privée dans les tombeaux égyptiens de l'Ancien Empire*, pp. 253–4).

barley, macerate it for a day with water, and then spread it for a day in a spot where it is well exposed to a current of air. Then for five hours moisten the whole once more, and place it in a vessel with handles, the bottom of which is pierced after the manner of a sieve.' The meaning of the next few lines is not clear, but according to Gruner the barley was then probably dried in the sun, in order that the husks, which are bitter and which would have imparted a like taste to the beer, might peel off. Continuing the description of Zosimos: 'The remainder must be ground up and a dough formed with it, after yeast has been added, just as is done in bread-making. Next the whole is put away in a warm place, and as soon as fermentation has set in sufficiently, the mass is squeezed through a cloth of coarse wool, or else through a fine sieve, and the sweet liquid is gathered. But others put the parched loaves into a vessel filled with water, and subject this to some heating, but not enough to bring the water to a boil. Then they remove the vessel from the fire, pour its contents into a sieve, warm the fluid once more, and then put it aside.'

Although Zosimos describes a primitive method of malting, which is almost identical with that used to-day in Cairo in making *bouza*, no evidence of malting can be identified, either in the tomb scenes or on the tomb models, and how far the practice (which is not essential) dates back is not known.

Statements have been made that the ancient Egyptians used bitter and other flavouring substances for their beer, much as hops are now employed, and that these included lupin[1]; skirret[1] (*Sium sisarum*); the root of an Assyrian plant[1]; rue[2, 3]; safflower[3, 4]; mandrake fruit[4]; bitter orange peel[5] and resin,[5] but the evidence (much of which is of very late date) is unsatisfactory and in some instances almost certainly refers to the use of beer as a vehicle for medicine and not to the flavouring of beer as a beverage. One authority often quoted is the Roman agricultural writer Columella, who says[6] '. . . the Egyptians made the sweetish taste of their Pelusian beer more palatable by adding to it

[1] J. G. Wilkinson, *The Ancient Egyptians*, 1890, I, p. 54.

[2] H. Schulze-Besse, *Bier u. Bierbereitung bei den Völkern der Urzeit*, I, *Babylonien u. Ägypten*, Geleitwort.

[3] E. Huber, *Bier u. Bierbereitung bei den Ägyptern*, in *Bier u. Bierbereitung bei den Völkern der Urzeit*, p. 43.

[4] M. Philippe, *Die Braukunst der Ägypter im Lichte heutiger Brautechnik*, in *Bier u. Bierbereitung bei den Völkern der Urzeit*, p. 55.

[5] J. Grüss, *Tagezeitung für Brauerei*, XXVII (1929), pp. 277–8.

[6] *De re rustica*, X, 114.

pungent spices and lupine.' According to Arnold, however,[1] 'This passage . . . must be interpreted differently. What he intends to say is that pungent or bitter substances were eaten with the beer of Pelusium, such as lupine, so as to stimulate the enjoyment, which was a custom likewise in vogue with the Romans who partook of such substances as appetisers.' With respect to the use of the mandrake fruit, both Gauthier[2] and Dawson[3] have shown that the ancient Egyptian word, thought at one time to mean mandrake, has been mistranslated and is the name of a mineral (red ochre) and not of a plant. The bitter orange peel and the resin thought to have been used were found on a tray of funerary offerings (Eleventh Dynasty) accompanying some bread which may have been beer-bread, though there is no proof of this, but their use in beer is very improbable. In modern Nubian *bouza* neither flavours nor bitters are employed, though the Abyssinians in Bruce's time added to their *bouza* the powdered bitter leaves of a certain tree called *ghesh*.[4] Montet thinks that sometimes at least a liquid made from crushed dates was added to the beer.[5] Although the evidence for this is very slight, such an addition might have been made, not to perfume the beer, as suggested by Montet, but to sweeten it, in the same manner as a special sugar (glucose) is added sometimes by modern English brewers to the fermented wort, the operation being termed 'priming.'

Naturally none of the ancient beer has remained to the present day and therefore it has not been possible to examine it, but dried residues from beer jars[6, 7, 8, 9] and also the dried and exhausted grain after 'mashing'[9] (i.e. maceration in water) have been discovered. A number of specimens of the former, ranging in date from the predynastic period to the Eighteenth Dynasty, have been examined by Dr. J. Grüss, of Berlin,[10, 11] who found them to consist of starch grains from the corn

[1] J. P. Arnold, *Origin and History of Beer*, p. 87.

[2] H. Gauthier, *Le nom hiéroglyphique de l'argile rouge d'Eléphantine*, in *Revue Egyptologique*, XI (1904), pp. 1–15.

[3] W. R. Dawson, *The Substance called Didi by the Egyptians*, in *Journal of the Royal Asiatic Society*, 1927, pp. 497–503.

[4] J. Bruce, *op. cit.*, pp. 65–6, 335. [5] P. Montet, *op. cit.*, p. 250.

[6] W. M. F. Petrie, *Prehistoric Egypt*, p. 43.

[7] H. E. Winlock, *Egyptian Expedition*, 1918–20, *Bull. Met. Mus. of Art, New York*, II (1920), p. 32.

[8] C. M. Firth, *Arch. Survey of Nubia, 1909–1910*, p. 17.

[9] W. M. F. Petrie, *Gizeh and Rifeh*, p. 23.

[10] J. Grüss, *Tagezeitung für Brauerei*, XXVI (1928), pp. 1123–4; XXVII (1929), pp. 275–8, 517, 679–82; XXVIII (1930), pp. 98, 774–6.

[11] H. E. Winlock, *The Tomb of Meryet-Amūn at Thebes*, pp. 32–3.

used (which was not barley, but a kind of wheat known as Emmer, the only wheat grown in Egypt until a late date); yeast cells; moulds; bacteria and small proportions of various impurities. The yeast was principally a variety of wild yeast, previously unknown, which Dr. Grüss named *Saccharomyces Winlocki* after Mr. H. E. Winlock, who supplied the material for examination. The Eighteenth Dynasty yeast was found to have cells approximating in size to the modern yeast and to be of a more uniform shape and freer from moulds and bacteria than the earlier yeast, from which Dr. Grüss concludes that the ancient Egyptian brewer had anticipated the modern brewer by making a pure, or almost pure, yeast culture.[1] The evidence, however, seems inadequate to support such a wide conclusion.

It may be mentioned that yeast is a uni-cellular plant belonging to the fungus family and is distributed abundantly throughout the world, being found wild on many plants (particularly on ripe fruits) and in the air: there are many varieties, two of the principal useful ones being the cultivated beer yeast (*Saccharomyces cerevisiae*) and the wild yeast (*Saccharomyces ellipsoideus*) which occurs on grapes and brings about vinous fermentation: many other yeasts also are known, but as some of them produce a bitter flavour, an objectionable taste or a persistent turbidity in the fermented liquid, these are avoided in modern brewing. On account of the ubiquity of yeast, fermentation is a natural process and when solutions containing certain kinds of sugar are exposed to the air, after a short time they begin to ferment.

Three Eighteenth Dynasty specimens of exhausted grain from Deir el Medineh[2] were examined by me and found to be barley. These I submitted for more detailed examination to Professor F. W. Oliver, who reported that 'The principal sample was a small form of 2-rowed barley (*Hordeum distichum*).'

Wine

Wine usually denotes the fermented juice of fresh grapes, and this was the principal wine of the ancient Egyptians, though they had also other kinds, namely, palm wine; date wine; according to Pliny[3] a further kind made from the *myxa* fruit and at a late date occasionally pomegranate wine, all of which may now be considered.

[1] J. Grüss, *op. cit.*, xxvii (1929), pp. 681–2.

[2] B. Bruyère, *Les fouilles de Deir el Médineh (1934–1935). La nécropole de l'est* (1937), p. 110.

[3] xiii: 10.

Grape Wine

Wine, meaning grape wine, is referred to frequently in the ancient Egyptian records,[1, 2] the earliest reference known to me being one of the Third Dynasty,[3] though the wine-press hieroglyph was used in the First Dynasty,[4] from which period wine jars also are known.

Wine is mentioned as being used for divine offering, for evening offering, for feast offering, for mortuary offering, for oblation, as a beverage and as being received as tribute.

Vintage scenes are often depicted upon tomb walls, thus to take a few examples, in a Fifth Dynasty tomb at Saqqara[5]; in a Sixth Dynasty tomb at Saqqara[6]; in a Twelfth Dynasty tomb at El Bersheh[7]; in several tombs of the same period at Beni Hasan[8]; in many others of Eighteenth and Nineteenth Dynasty dates respectively in the Theban necropolis,[9, 10] and in a tomb of the Saïte period[11] the gathering, treading or pressing of grapes, or all three of these operations, are shown.[12]

The preparation of wine is a comparatively simple matter, all that is necessary being to crush the grapes in order to free the juice, which is separated from the stalks, skins and stones and then allowed to ferment, which it does naturally, chiefly by means of the wild yeasts (principally *Saccharomyces ellipsoideus* but also *S. apiculatus*) present on the skins of the grapes, but also to some extent by the action of certain enzymes (largely zymase) present in the juice. The fermentation consists in the conversion of the sugars present in the juice [these being

[1] J. H. Breasted, *op. cit.*, v (Index), p. 170. [2] A. Erman, *op. cit.*

[3] J. H. Breasted, *op. cit.*, I, 173.

[4] W. M. F. Petrie, *Social Life in Ancient Egypt*, pp. 102, 135.

[5] N. de G. Davies, *The Mastaba of Ptahhetep and Akhethetep at Saqqarah*, I, Pls. XXI, XXIII.

[6] The tomb of Mereruka (Mera).

[7] P. E. Newberry, *El Bersheh*, I, Pls. XXIV, XXVI, XXXI.

[8] P. E. Newberry, *Beni Hasan*, I, Pls. XII, XLVI; II, Pls. VI, XVI.

[9] N. de G. Davies, *The Tomb of Nakht at Thebes*, Pls. XXII, XXIII, XXVI; *The Tomb of Puyemrê at Thebes*, Pls. XII, XIII; *The Tomb of Two Officials of Tuthmosis the Fourth*, Pl. XXX; *Five Theban Tombs*, Pl. XXXI; *Two Ramesside Tombs at Thebes*, Pls. XXX, XXXII, XXXIII; *The Tomb of Nefer-Hotep at Thebes*, I, Pl. XLVIII.

[10] A. E. Weigall, *A Guide to the Antiquities of Upper Egypt*, 1913, pp. 115, 123, 139, 160, 178.

[11] A. Lansing, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1916–1919* (1920), p. 21.

[12] See also (*a*) H. F. Lutz, *op. cit.*; (*b*) P. Montet, *La culture de la vigne et vendanges, op. cit.*, pp. 265–73; (*c*) P. Montet, *La fabrication du vin dans les tombeaux antérieurs au Nouvel Empire*, in *Recueil de travaux*, XXXV (1913), pp. 117–24.

glucose (dextrose) and fructose (levulose)] into alcohol and carbon dioxide.

According to the scenes on the tomb walls already referred to, the grapes were crushed by treading until no more juice could be extracted. This method is still used largely to-day in France and Spain, because it gives results that in many ways are better than those obtained by mechanical presses, the great advantage of the human foot being that while it crushes the grapes perfectly it does not crush the stalks or stones, which a press tends to do, so liberating undesirable astringent and colouring matters. After treading, the residue was placed in a cloth or bag, which was tightly twisted in order to squeeze out the remaining juice, a method still used in the Fayum at the beginning of the nineteenth century.[1] The juice then was poured into large pottery jars, where it fermented, but there is nothing to show whether the juice from the treading was mixed with that from the squeezing, or whether the two lots were fermented separately. The latter, having been in contact with the stalks, seeds and skins for a longer period, would have been the more astringent and the more highly coloured of the two, as when fermentation had produced alcohol, this would have extracted astringent substances from the stalks and seeds and, if 'black' grapes were used, also considerable colouring matter from the skins.

The colour of wine depends upon the colour of the grapes and whether or not the skins are included in the fermentation. 'White' grapes naturally produce white wine, the juice being colourless, and, as the juice of 'black' grapes is also usually colourless,[2] these, too, will produce white wine, if the skins are separated before fermentation, though if the skins are not removed a red wine is obtained.

No literary reference to the colour of the grapes grown anciently in Egypt can be traced, and Miss C. Ricci states[3] that even in the Graeco-Roman papyri the colour is not mentioned, but the grapes shown on several tomb walls of the New Empire at Thebes are dark-coloured.[4] Erman states that under the Old Empire the wine included white, red and black varieties.[5] Petrie

[1] P. S. Girard, *Description de l'Égypte, état moderne*, II, *Mém. sur l'agriculture, l'industrie et le commerce de l'Égypte*, 1812, p. 608.

[2] Some few kinds of 'black' grapes give a coloured juice.

[3] C. Ricci, *La coltura della vite e la fabricazione del vino nell' Egitto Greco-Romano*, 1924, p. 61.

[4] N. de G. Davies, (*a*) *The Tomb of Nakht at Thebes*, Frontispiece, Pls. XXV, XXVI; (*b*) *Two Ramesside Tombs at Thebes*, Pl. XXXIII.

[5] A. Erman, *Life in Ancient Egypt*, 1894, p. 196.

says[1] ' In the Old Kingdom only dark grapes are represented, and the wine must have been red. At El Bersheh in the XIIth dynasty white grapes are seen and the juice is light, such as would make white wine.' In a Middle Kingdom tomb at Meir white wine is mentioned.[2] Athenaeus refers to the Egyptian wine varying in colour and mentions both white and pale wine.[3] It seems probable, therefore, that both light and dark grapes were used.

The amount of alcohol produced in wine by fermentation is limited by two factors, one being the quantity of sugar present in the grapes and the other being the fact that the yeast is killed (with the consequent gradual slowing down and final arrest of the fermentation) by the alcohol formed when the proportion reaches about 14 per cent,[4] although there may still be fermentable sugar present and, if the grapes used are rich in sugar, the portion that escapes fermentation remains, imparting sweetness to the wine.

In ancient Egypt, on account of the slow method of pressing adopted and the high temperature towards the end of the summer, when the vintage must have taken place, the fermentation would almost certainly have commenced before all the juice was extracted, but it occurred principally in the large jars to which the juice is shown as being transferred while the pressing is still going on. These jars necessarily must have been left open until the fermentation had almost ceased, otherwise they would have burst from the pressure of carbon dioxide generated; but when the fermentation was almost over the jars were stoppered with ' a wad of vine leaves ' over which ' was moulded roughly with the fingers to a height of about 10 cm. a tenacious mixture of black earth and chopped straw,' as found by Winlock at the Christian Monastery of Epiphanius at Thebes,[5] or with ' a rush bung completely covered over with a clay or mud capsule that enveloped the whole of the mouth and neck of the jar ' in the manner of those found by Carter in the tomb of Tut-ankhamun,[6] or with such variant of the method as the local conditions and the importance of the wine demanded. Wine jars stoppered and sealed are represented in a number

[1] W. M. F. Petrie, Review in *Ancient Egypt*, 1914, p. 38. See also P. Montet, *Recueil de travaux*, xxxv (1913), pp. 117–8.

[2] A. M. Blackman, *The Rock Tombs of Meir*, III, p. 30. [3] I: 33.

[4] The excess of alcohol above about 14 per cent in certain modern wines is due to the addition of extra alcohol.

[5] H. E. Winlock and W. E. Crum, *The Monastery of Epiphanius at Thebes*, I, p. 79.

[6] Howard Carter, *The Tomb of Tut-ankh-Amen*, III, p. 148; Pl. L.

of tombs, for example, in one of the Twelfth Dynasty at Beni Hasan[1] and in two of the Eighteenth Dynasty at Thebes, namely, in that of Nakht and in that of Nefer-Hotep.[2] The closing of the jars as soon as possible was essential, since if the wine had been left exposed to the air, another kind of fermentation (the acetous fermentation) caused by a minute organism (*Mycoderma aceti*), always present in the air, would have taken place, which would have converted the alcohol into acetic acid and the wine would have become vinegar. The jars, however, were not all sealed hermetically at this stage, since in some instances slow fermentation was still going on, in which case a small hole was drilled in the neck of the jar, or made in the stopper, as shown in some of those from the Monastery of Epiphanius[3]; in those from the tomb of Tut-ankhamun[4]; and in a large number of local ware of Graeco-Roman date from Meydum,[5] in order to provide a way of escape for the carbon dioxide being given off in small amount, and, when the fermentation was finished, this hole was sometimes 'stopped with a wisp of straw'[3] and sometimes closed with clay and sealed.[4] At the Monastery of Epiphanius only about half the jars had been provided with this small vent.[3] Doubtless occasionally a jar would be sealed finally before fermentation had ceased, and in such a case the internal pressure might be sufficient to break the jar, as appears to have occurred with one of those from the tomb of Tut-ankhamun, where the neck seems to have been ruptured and the contents to have flowed down the outside of the jar.

During the Graeco-Roman and Coptic periods wine jars[6] were rendered impermeable by being treated inside with a thin coating of resin, which is always black, the colour probably being due to the charring of a non-black resin by the heat necessary to render it sufficiently liquid to flow as a thin layer over the inside of the jar. A deposit of similar black resin is found often at the apex of the jars that have been treated in this manner.[7] Wine jars blackened inside were

[1] P. E. Newberry, *Beni Hasan*, I, Pl. XII.

[2] N. de G. Davies, (*a*) *The Tomb of Nakht at Thebes*, p. 70, Pl. XXVI; (*b*) *The Tomb of Nefer-Hotep at Thebes*, Pl. XLVIII.

[3] H. E. Winlock and W. E. Crum, *op. cit.*, p. 79.

[4] Howard Carter, *op. cit.*, pp. 148–9.

[5] Found by Mr. Alan Rowe, to whom I am indebted for the information.

[6] Possibly also jars for containing liquids other than wine, such as oil or honey.

[7] Several specimens of the black coating and the black material from the apex of wine jars of the Graeco-Roman period have been analysed by me and found to be resin in every case. See C. C. Edgar, *Zenon Papyri*, III, No. 59481; IV, No. 59741.

discovered at the Monastery of Epiphanius at Thebes by Winlock, who in describing them says, 'Like the Greek wine jars the inside was coated with a black resinous pitch . . .'[1] This practice was known also to the Romans, since Pliny[2] refers to 'The pitch (i.e. blackened resin) . . . for preparing vessels for storing wine . . .' With reference to the wine jars from the tomb of Tut-ankhamun, Carter states[3] that 'In all probability the interior of the jars was smeared over with a thin coat of resinous material to counteract the porous nature of the pottery; the broken specimens show a distinct black coating on their inner surface.' I have examined twenty-two wine jars or parts of wine jars from this tomb,[4] of which twenty were broken, ten of them being much broken, thus making the examination a fairly easy matter. The outsides of the jars vary considerably in colour, some being entirely greenish-grey, some entirely red and some partly one colour and partly the other. The insides of the jars are chiefly light-red, though occasionally drab with a reddish tint, but in no instance is there any blackening of the nature of that on the Graeco-Roman wine jars, no resin at the apex and no continuous black coating of any sort, though in some cases there are black spots and small black patches that look very like fungus growths (which they probably are) but in most cases there is not any blackening at all.[5] The edges of the broken surfaces vary in colour from a drab with a slight reddish tint to light-red, mottled in every instance with innumerable white particles, which on testing proved to be calcium carbonate (carbonate of lime). There cannot be any doubt, therefore, that the clay used for these jars was calcarious (i.e. contained calcium carbonate), which explains both the greenish-grey and the red colours, the former being where the jars have been strongly heated and the latter where the heat has been less intense.[6] No evidence of any slip could be found, either inside or outside the jars, and it must be assumed, therefore, that they were sufficiently watertight for the purpose required without either slip or resin coating.[7] That they were not absolutely

[1] H. E. Winlock and W. E. Crum, *op. cit.*, p. 79.

[2] XIV : 25. [3] *Op. cit.*, pp. 148–9.

[4] Five were of the long-necked Syrian type. Fourteen other jars from this tomb were not examined, since nine are still stoppered and sealed, and five, including two additional ones of the Syrian type, are in the Museum show case.

[5] One jar with a broken neck (No. 541) was rinsed with water inside and that it was entirely free from blackening was confirmed.

[6] See p. 438.

[7] One jar (No. 541) was filled with water and allowed to stand for forty-six hours; there was no leakage of water and the jar was not even damp on the outside.

impermeable seems to be proved by the fact that those of the jars that are unbroken and still stoppered and sealed are empty.

Lutz states[1] that 'The Egyptians, before pouring the wine into the jars, generally smeared the bottoms with resin or bitumen. This was done in order to preserve the wine. It was also thought to improve the flavour of the wine.' No evidence whatever has been found for the use of bitumen in wine jars, nor of the use of resin before the Graeco-Roman period, when the whole of the inside of the jar, not merely the bottom, was coated with resin, which was done to make the jar impermeable and not to preserve the wine (except from evaporation), nor to improve its flavour.

In a Middle Kingdom tomb at Meir wine of eastern Buto, wine of Mareotis and wine of Syene are mentioned[2]; in the Eighteenth Dynasty wine was being obtained from the eastern and western Delta[3]; from the Oasis of Kharga[4]; and as tribute from Asia (Arvad, Zahi and Retenu)[5]: in the Twenty-second and Twenty-sixth Dynasties respectively it was obtained from the oases of the western desert[6] and in the Twenty-sixth Dynasty from the western Delta.[6]

Herodotus strangely enough says that there were no vines in Egypt,[7] though he mentions that the Egyptian priests drank wine[8] and used it in the temple sacrifices[9] and that wine was consumed at certain festivals,[10] but since he records the importation of wine into Egypt from Greece and Phoenicia,[11] he may have thought that all the wine used in the country was of foreign origin.

Diodorus refers to the vines of Egypt[12] and to the drinking of wine.[13]

Strabo states[14] that Libyan wine, which he says was mixed with sea water, was of poor quality, but that another Egyptian wine, the Mareotic, made in large quantity, was good; he also refers to wine from an oasis in the western desert[15] and to wine from the Fayum province,[16] which latter he says was produced in abundance.

Pliny, in his enumeration of wines foreign to Italy, includes a kind

[1] H. F. Lutz, *op. cit.*, pp. 56–7.
[2] A. M. Blackman, *The Rock Tombs at Meir*, III, p. 30.
[3] Howard Carter, *The Tomb of Tut-ankh-Amen*, III, p. 147.
[4] H. W. Fairman, in *The City of Akhenaten*, II, H. Frankfort and J. D. S. Pendlebury, p. 105.
[5] J. H. Breasted, *op. cit.*, V (Index), p. 170.
[6] J. H. Breasted, *op. cit.*, IV, 734, 992.
[7] II: 77.
[8] II: 37.
[9] II: 39.
[10] II: 60.
[11] III: 6.
[12] I: 3.
[13] I: 4.
[14] XVII: 1, 14.
[15] XVII: 1, 42.
[16] XVII: 1, 35.

termed Sebennys, made in Egypt, from three different varieties of grapes 'of the very highest quality,'[1] namely, the Thasian grape, the 'smoky' grape and the 'pitchy' grape. The Thasian grape, probably so called because it had been introduced into Egypt from Thasos, is described[2] as being 'remarkable for its sweetness and laxative qualities.' Pliny also mentions an Egyptian wine that he states produced miscarriage.[2]

Athenaeus quotes Hellanicus for the statement that the vine was first discovered in Egypt,[3] and he quotes Dio as saying that the Egyptians were fond of wine and bibulous,[3] and he himself calls them wine-bibbers[3]: he states,[3] too, that 'The vine is as abundant in the Nile valley as its waters are copious, and the peculiar differences of the wines are many, varying with colour and taste': he says also[4] that the vine was abundant in the Mareotic region in the neighbourhood of Alexandria and that its grapes were 'very good to eat': he mentions several wines,[4] namely the Mareotic (excellent, white, pleasant, fragrant, easily assimilated, thin, does not go to the head, diuretic); the Taeniotic (better than the Mareotic, somewhat pale, has an oily quality, pleasant, aromatic, mildly astringent); the wine of Antylla, a city not far from Alexandria (surpassing all others), and the wine of the Thebaid and especially that from the city of the Copts ('so thin and assimilable, so easily digested, that it may be given even to fever patients without injury'). This same writer states also[5] that the Egyptians used boiled cabbage and cabbage seeds as remedies against drunkenness and subsequent headache. With reference to the mixing of sea water and wine mentioned by Strabo[6] as being practised with the Libyan wine, Athenaeus states[7] that 'Wines which are more carefully treated with sea water do not cause headache; they loosen the bowels, excite the stomach, cause inflation, and assist digestion.' This practice of mixing sea water with wine is mentioned also by Pliny,[8] according to whom, if done sparingly, it was thought to improve the flavour of the wine, though of one wine so treated he states[8] that it 'is far from wholesome.'

There is no recorded instance known to me of wine having been discovered in an Egyptian tomb, though wine jars and clay sealings from wine jars are very common. In some of the jars, however, there are the residues left after the evaporation of the liquid and I have

[1] XIV: 9. [2] XIV: 22. [3] I: 34.
[4] I: 33. [5] I: 34. [6] XVII: 1, 14.
[7] I: 32. [8] XIV: 9.

analysed three such residues, two from the tomb of Tut-ankhamun[1] and one from the Monastery of St. Simeon near Aswan,[2] the potassium carbonate and potassium tartrate found proving that the residues were those from wine.

Palm Wine

A wine-producing palm is mentioned in the Pyramid Texts[3] and both Herodotus[4] and Diodorus[5] state that palm wine was used in Egypt to wash out the abdominal cavity during the process of mummification and Herodotus relates that Cambyses sent a cask of palm wine to Ethiopia.[6] Wilkinson says[7] that palm wine was made in Egypt in his day and that it consisted of the sap of the date palm obtained by making an incision in the heart of the tree, immediately below the base of the upper branches and that, as taken directly from the tree, the liquid was not intoxicating, but acquired this property by fermentation when kept and that the wine resembled in flavour a very light new grape wine: he states also that a palm tapped in the manner described was rendered useless for fruit bearing and generally died. Beadnell states that 'In the oases and other parts of Egypt a fermented liquor . . . is obtained by making a deep incision in the top of the date palm . . .' 'the palm may be bled once or twice a month without sustaining any harm: the operation may, in fact, prove of considerable benefit to a sickly palm.'[8] Oric Bates states[9] that an intoxicant is made in eastern Libya by fermenting the sap of the date palm. In Egypt, too, a similar wine is occasionally prepared, but always from a male tree that is not required, which often dies as the result of the operation and is cut down. The fermentation of the sap is brought about by means of wild yeasts present on the tree and in the air.

Bruijning suggests[10] that the palm wine used anciently in Egypt was

[1] A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, III, Appendix II, p. 183. A second specimen was subsequently examined.

[2] In this Monastery there may still be seen a complete installation for making wine. (*U. Monneret de Villard, Un Pressoio da Vino dell' Egitto Medioevale*, in *Reale Instituto Lombardo di Scienze e Lettere*, LIX, XI–XV, 1926; also *Descrizione Gen. del Monastero di S. Simeone presso Aswan*, in *Annales du Service*, XXVI (1926), p. 231.

[3] F. F. Bruijning, *The Tree of the Herakleopolite Nome*, in *Ancient Egypt*, 1922, pp. 1–8.

[4] II: 86. [5] I: 7. [6] III: 20.

[7] J. G. Wilkinson, *The Ancient Egyptians*, 1890, I, p. 55.

[8] H. J. L. Beadnell, *An Egyptian Oasis*, p. 218.

[9] Oric Bates, *The Eastern Libyans*, p. 26.

[10] F. F. Bruijning, *op. cit.*, pp. 3, 7.

obtained, not from the date palm, but from other species of palm, such as the Raphia palm, probably *Raphia monobuttorum*, which he thinks may have grown in Egypt at one time, though it is not now found in the country. It is true that the Raphia palm, which is an African tree, often found growing in forest swamps, does yield a wine and is used for wine making in certain parts of Africa and that it is sometimes called the *Nakhl el Faraoon* (Pharaoh's date palm),[1] but there is no evidence that it ever grew in Egypt and, as the palm wine made at the present time is from the date palm, there is no reason to think that it was otherwise anciently.

Date Wine

Date wine is mentioned occasionally in the ancient Egyptian records, for example in the Sixth Dynasty[2] and on two ostraca of the Nineteenth Dynasty in the Cairo Museum: it is described also by Pliny, who states[3] that it was made 'throughout all the countries of the East,' which probably was meant to include Egypt, though Egypt is not specifically named. It was prepared by steeping a certain kind of date in water and pressing out the liquid, which was left to ferment, which it did naturally from the wild yeasts present on the dates. A similar beverage is described by Burckhardt[4] as being made in Nubia by boiling ripe dates with water, straining the liquid and allowing it to ferment. Oric Bates states that in eastern Libya an intoxicant is made by fermenting dates.[5] A date wine, such as that described, was, and still is, made in Egypt sometimes, but instead of being drunk as wine, the liquid is distilled and the resulting spirit consumed.

Myxa Wine

With respect to the Myxa wine stated by Pliny[6] to have been made in Egypt, no other mention of it can be traced. The Myxa (*Cordia Myxa*), which is cultivated in gardens in Egypt, bears a mucilaginous fruit, which Theophrastus, who calls it 'the Egyptian plum,'[7] describes without referring to any use having been made of it for wine making, although he states that it was made into cakes. Some part of the tree, probably the fruit, was identified by Newberry from the Graeco-Roman cemetery at Hawara,[8] and thick layers of the leaves were found by

[1] G. Schweinfurth, *The Heart of Africa*, I, p. 199.
[2] J. H. Breasted, *op. cit.*, I, 336.
[3] XIII: 9; XIV: 19.
[4] J. L. Burckhardt, *op. cit.*, p. 143.
[5] Oric Bates, *op. cit.*, p. 26.
[6] XIII: 10.
[7] *Enquiry into Plants*, IV: 2, 10.
[8] P. E. Newberry, in *Hawara, Biahmu and Arsinoe*, W. M. F. Petrie, pp. 48, 53.

Davies at Sheikh Saïd which were of late date, probably Coptic,[1] and Griffith found seeds and fruits, probably of similar late date, at Faras in Nubia which are now in the Museum of the Royal Botanic Gardens, Kew.[2]

Pomegranate Wine

The only reference to pomegranate wine in Egypt that can be found is in a late third century A.D. papyrus,[3] although it was known to the Greeks as a medicine.[4] Lutz states[5] that the Egyptians used pomegranate wine, but Peet says[6] that ' The identification is a pure guess '; he also says[6] that the ' fig-wine ' mentioned by Lutz is not fig-wine but simply two baskets of figs.

Distilled Spirits

Distillation is the process of converting a volatile liquid into vapour by heat and then recondensing it again by cooling, and distilled spirits are naturally-flavoured solutions of alcohol in water that have been made by the distillation of certain fermented liquids.

Although the ancient Egyptians made beer and wine, both of which contain alcohol, they were unacquainted with distillation and, therefore, did not know distilled spirits.

When and where the discovery of distillation took place there is no evidence to show, but the first mention of it that can be traced is by Aristotle in the fourth century B.C., who describes the formation of mist and rain[7] (which are caused by natural processes of evaporation and condensation) and who also says,[8] ' Salt water when it turns into vapour becomes sweet and the vapour does not form salt water when it condenses again. This I know by experiment. The same thing is true in every case of the kind: wine and all fluids that evaporate and condense back into a liquid state become water. They are all water modified by a certain admixture, the nature of which determines their flavour.' Evidently Aristotle, although he had distilled wine and made dilute alcohol, did not recognize it as anything other than water ' modified by a certain admixture,' the nature of which determined its flavour.

[1] N de G. Davies, *The Rock Tombs of Sheikh Saïd*, p. 4.
[2] No. 86/1913.
[3] A. S. Hunt, *The Oxyrhynchus Papyri*, VIII, p. 241.
[4] R. W. T. Gunther, *The Greek Herbal of Dioscorides*, V, 34.
[5] H. F. Lutz, *op. cit.*, p. 9.
[6] T. E. Peet, *Liverpool Annals of Archaeology and Anthropology*, X (1923), p. 53.
[7] *Meteorologica*, I: 9, 11. [8] *Op. cit.*: II, 3.

Theophrastus (fourth to third century B.C.) had some knowledge of a method of destructive distillation for obtaining wood tar, which he describes,[1] and Pliny (first century A.D.) also knew of this,[2] as well as of a primitive method of obtaining spirits of turpentine by means of distillation.[3]

Zosimos, who is ' the most ancient alchemical author of whom we have genuine writings and can identify '[4] describes and illustrates a variety of retorts and recipients, thus proving that distillation was well known in his time (the end of the third century A.D. or the beginning of the fourth), but he makes no mention whatever of alcohol, and it is highly probable that this was not known until the Middle Ages, its use at first being medicinal and not as a beverage.

SUGAR

In connexion with beer and wine, the use of sugar in ancient Egypt may be dealt with conveniently, as it was from sugar that the alcohol, which imparted the stimulating and intoxicating properties to both these beverages was derived. In the case of beer, sugar, as already described, was produced during the preliminary processes of brewing from the starch present in the grain used, while with wine, the sugar existed ready formed in the grapes, palm juice, dates and other materials employed.

Although sugar is distributed widely in nature, being present as honey, in milk and in certain trees, plants, roots, flowers and fruits, it was known anciently only in the form of honey, sugar from the sugar cane being of comparatively late date and that from the beetroot being still more recent.

Cane Sugar

The sugar cane is a native of the Far East and seems to have been first cultivated in India and the sugar from it was just becoming known to the Roman world in Pliny's time though only as a medicine.[5] From this same period (first century A.D.) there is a record of sugar or ' honey from the reed called sacchari ' as it is termed, having been shipped from India to the Somali coast,[6] and Dioscorides (also first century A.D.)

[1] *Enquiry into Plants*, IX: 3, 1–3. [2] XVI: 21–2.
[3] XV: 7. [4] E. J. Holmyard, *Makers of Chemistry*, p. 35.
[5] XII: 17. [6] W. H. Schoff, *The Periplus of the Erythræan Sea*, pp. 27, 90, 285.

states[1] that there is a kind of 'concreted' honey, called sugar, found in reeds in India and Arabia 'like in consistence to salt, and brittle to be broken between the teeth as salt is.' The bare facts of the existence of sugar cane and the extraction of sugar from it, however, seem to have been known in Greece several centuries earlier than the date mentioned, as Nearchus (fourth century B.C.) is quoted by Strabo[2] (first century B.C. to first century A.D.) for the statement that 'reeds yield honey, although there are no bees . . .'; he also says that there was 'a tree from the fruit of which honey is procured . . .', the identity of which, however, unfortunately is not recorded. Pliny states that Arabia as well as India produced sugar.

So far as can be ascertained there is no mention of sugar from the sugar cane in any ancient Egyptian document, not even in the late Greek papyri, and the only sources of sugar readily available were honey, and such fruits as dates and grapes; but it was honey that took the place in daily life of the modern sugar, the sugar cane, now so largely grown in the country being a comparatively modern introduction. In the thirteenth century Marco Polo states[3] that certain Egyptians, skilled in the matter, instructed the inhabitants of Un-guen (China) in a method of refining sugar by means of wood ashes.

Honey[4]

Bee-keeping was one of the important minor industries in ancient Egypt and honey is mentioned frequently in the ancient records,[5, 6] the earliest references to it that can be traced being of the Sixth Dynasty[7, 8]: in the Eighteenth Dynasty it is named among various mortuary offerings[9] and in this same dynasty it was included in the tribute from both Zahi[10] and Retenu[11] in Asia and in the Nineteenth Dynasty it is mentioned as part of the rations of the king's messenger and standard

[1] R. T. Gunther, *The Greek Herbal of Dioscorides*, II, 104.
[2] XV: 1, 20.
[3] Marco Polo, *Travels*, p. 316. (Everyman's Library.)
[4] See Bibliography, L. Armbruster, *Die Biene im Orient* 1. *Der über 5000 Jahre alte Bienenstand Aegyptens* (*Archiv für Bienenkunde, 1931*).
[5] J. H. Breasted, *op. cit.*, V (Index), p. 132.
[6] A. Erman, *The Literature of the Ancient Egyptians.*
[7] J. H. Breasted, *op. cit.*, I, 366.
[8] Papyrus in the Cairo Museum, No. J. 15,000.
[9] J. H. Breasted, *op. cit.*, II, 571.
[10] J. H. Breasted, *op. cit.*, II, 462.
[11] J. H. Breasted, *op. cit.*, II, 518.

bearer.[1] In both the Edwin Smith Surgical Papyrus (seventeenth century B.C.)[2] and in the Papyrus Ebers (about 1500 B.C.)[3] honey is mentioned as a frequent ingredient in medicine: in a Middle Kingdom scene, now in the Berlin Museum, the taking of honey is shown[4]: in the Eighteenth Dynasty tomb of Rekhmara at Thebes jars of honey are depicted and named[5] and in the tomb of Pabasa at Thebes (Saïte period) a scene of bee-keeping is shown.[6] In the Ptolemaic period 'there were royal as well as private bee-farms.'[7]

Two small pottery jars of Eighteenth Dynasty date from the tomb of Tut-ankhamun, each marked in hieratic 'honey of good quality,' examined by me were practically empty, except for a trace of dried material adhering to the inside. In one case I analysed this, so far as was possible with the very small quantity available, with the result that the chemical tests were negative, the only indication of sugar being a slight smell suggestive of caramel (burnt sugar) when the material was treated with hot water, in which twenty-six per cent was soluble. Another specimen from the New Kingdom submitted by Dr. L. Keimer as honey was entirely insoluble in water and gave no reaction whatever for sugar. These negative results, however, do not necessarily mean that the specimens had not been honey at one time, but merely indicate that, if honey, they had become so changed that they responded no longer to the usual tests.

A material found in considerable amount in a large alabaster jar in the tomb of Tut-ankhamun[8] was black and resinous-looking, with the upper surface covered with the chitinous remains of a very large number of small beetles: there were signs that at one time the substance had been viscous and had run, and throughout the black mass there were innumerable small translucent light-brown crystals. The bulk of the substance could not be identified, but the crystals were sweet, soluble in water and gave all the chemical reactions for sugar, which they undoubtedly were. What the material had been originally

[1] J. H. Breasted, *op. cit.*, III, 208.

[2] J. H. Breasted, *The Edwin Smith Surgical Papyrus*, Index, p. 583.

[3] C. P. Bryan, *The Papyrus Ebers.*

[4] L. Klebs, *Die Reliefs und Malereien des Mittleren Reiches*, pp. 83–4; Abb. 57.

[5] P. E. Newberry, *The Life of Rekhmara*, pp. 29–33, 35; Pls. XIII, XIV.

[6] A. Lansing, *The Egyptian Expedition, 1916–1919*, in *Bull. Met. Mus. of Art, New York*, II (1920), pp. 21–2.

[7] E. Bevan, *A History of Egypt under the Ptolemaic Dynasty*, p. 149.

[8] A. Lucas, *Appendix* II, p. 183, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter.

it is impossible to say, but honey or a fruit juice, such as grape juice or date extract, is suggested.

It is stated that the Egyptians sometimes preserved their dead in honey[1]; but, if so, this was very exceptional, and the body of Alexander the Great, which is quoted as an example,[1] if so embalmed, was presumably treated in Babylon, where he died, and not in Egypt, and it was the preserved body that was brought to Egypt.

Date Extract

The possible use of this as a sweetening material in beer has already been suggested, but the evidence for its use in this, or in any other connexion, is practically nil.

Grape Juice

That the Egyptians used unfermented grape juice, probably evaporated to a syrup, as a sweetening material, is proved by the finding in the tomb of Tut-ankhamun part of a pottery jar, similar in size and shape to the wine jars from the same tomb, bearing an inscription in hieratic to the effect that the jar contained unfermented grape juice of very good quality from the temple of Aten.[2] Grape syrup is mentioned in a papyrus of late date[3] and it is still much used in Syria at the present day, where it is called *dibs*. Two specimens of glossy, black, resinous-looking material of Eighteenth Dynasty date found by Bruyère at Deir el Medineh, which I examined, contained 17.0 per cent and 24.4 per cent respectively of glucose and were probably either honey, as stated by the finder,[4] or grape syrup, and a third specimen of amorphous black material containing tiny white crystals (which were not identified) of the same date and place was probably similar.

On a tomb wall (Twelfth Dynasty) at Beni Hasan, in close connexion with a vintage scene, a man is shown stirring a liquid in a pot on a fire and, adjoining this, a liquid is being strained through a cloth.[5]

[1] E. A. Wallis Budge, *The Mummy*, 2nd edition (1925), p. 208.

[2] Cairo Museum, No. J. 62324.

[3] C. C. Edgar, *Zenon Papyri in the University of Michigan Collection*, 1931, No. 65.

[4] B. Bruyère, *Les fouilles de Deir el Médineh (1934–1935); La nécropole de l'est*, 1937, p. 109.

[5] P. E. Newberry, *Beni Hasan*, II, Pl. VI.

Several writers have suggested that this may refer to the production of grape syrup.[1] In the first century A.D. the juice of sour grapes,[2] which Dioscorides calls *omphacion*,[3] and Pliny *omphacium*,[4] from Diospolis was exported.

[1] R. Dage et A. Aribaud, *Le vin sous les pharaons*, 1932, p. 50: A. Neuburger, Trans. H. L. Brose, *The Technical Arts and Sciences of the Ancients*, 1930, Fig. 170.

[2] W. H. Schoff, *The Periplus of the Erythræan Sea*, pp. 25, 75.

[3] R. T. Gunther, *The Greek Herbal of Dioscorides*, v: 6.

[4] XII: 60; XXIII: 4.

CHAPTER III

ANIMAL PRODUCTS

It has been found convenient to group together in the same chapter various products of the animal kingdom, namely, Bone; Feathers; Gut; Hair; Horn; Ivory; Leather; Mother of Pearl; Ostrich Egg-shell; Parchment; Tortoise-shell and Marine and Fresh Water Shells, all of which may now separately be considered.

Bone

Bone was one of the most natural materials for primitive man to use, since generally it was plentiful and was easily splintered and pointed (in the case of certain fish bones it was already pointed) and so, without difficulty, it could be made into small boring implements, such as awls and needles: it was also suitable for carving upon.

Animal bones were used in ancient Egypt from neolithic times[1, 2] through all the subsequent periods, being made into various small objects, principally amulets, arrow heads, awls, beads, bracelets, combs, finger rings, harpoon heads, needles and pins. Fish vertebrae were occasionally made into beads[3] and pointed fish bones into needles,[4] or awls.[5]

In addition to fresh bone, fossil bone was occasionally also used, a mirror handle made of this material being known.[6]

Feathers

In most countries the use of feathers is known from very early times and in Egypt, which is no exception, the custom can be traced back

[1] G. Caton-Thompson, *The Neolithic Industry of the Northern Fayum Desert*, in *Journal, Royal Anthrop. Inst.*, LVI (1926), pp. 310, 312.
[2] H. Junker, *Merimde-Benisalâme*, 1929, p. 237; 1930, pp. 71–2.
[3] G. A. Wainwright, *Balabish*, p. 21.
[4] T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 17.
[5] G. Brunton, *Mostagedda*, pp. 58, 90.
[6] D. E. Derry, *Man*, 1937, 134.

to the Tasian[1] and Badarian periods.[2] The feathers employed were chiefly those of the ostrich, though feathers possibly from the night heron[3]; the crow or raven[4, 5]; and a water-fowl[6] respectively have also been found in tombs, and in one instance pigeon feathers.[7]

Ostrich feathers were used largely for fans and as a head ornament, thus Piankhi (Twenty-fifth Dynasty) received the submission of 'all the chiefs who wore the feather'[8] (probably ostrich feathers): the goddess Maat, various gods and chariot horses are often depicted wearing ostrich feathers: in the Middle Kingdom Egyptian colony at Kerma in the Sudan ostrich feathers were used for making both fans and rugs.[9] Both the water-fowl feathers and the pigeon feathers referred to were employed to stuff cushions.

Although the ostrich is not now found in Egypt, it was fairly common until a very late period in both the eastern and western deserts and in the Eighteenth Dynasty it evidently existed as far north as Heliopolis, since on the handle of a fan from the tomb of Tut-ankhamun the king is shown shooting ostriches with a bow and arrow and an inscription states that the hunt took place in 'the eastern desert of Heliopolis.'[10] On the other side of the fan the king has a bundle of ostrich feathers under his arm and the servants are carrying two dead ostriches. On one fan from this tomb the ostrich feathers still remain.

The local ostrich, however, apparently was not plentiful enough to supply all the feathers required, as some were imported, thus on the wall connecting the two pylons of Horemheb at Karnak ostrich feathers are shown being brought from Punt[11] and, on one of the walls of the temple of Beit el Wali in Nubia, Ramesses II is depicted receiving Nubian tribute, which includes ostrich feathers.[12]

[1] G. Brunton, *Mostagedda*, p. 29.

[2] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 28, 38.

[3] G. Brunton, *Mostagedda*, p. 58.

[4] G. A. Wainwright, *op. cit.*, p. 12.

[5] C. M. Firth, *Arch. Survey of Nubia, Report for 1908–1909*, p. 58.

[6] British Museum, *A Guide to the Fourth, Fifth and Sixth Egyptian Rooms*, 1922, p. 87.

[7] J. E. Quibell, *The Tomb of Yuaa and Thuiu*, p. 52.

[8] J. H. Breasted, *op. cit.*, IV, 873.

[9] G. A. Reisner, *Excavations at Kerma*, IV–V, pp. 300–1, 315.

[10] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 46.

[11] J. H. Breasted, *op. cit.*, III, 37.

[12] J. H. Breasted, *op. cit.*, III, 475.

In several Eighteenth Dynasty tombs at Thebes ostrich feathers are pictured.[1, 2, 3, 4]

Gut

Gut, that cannot be distinguished from modern gut, was employed in ancient Egypt for the strings of musical instruments and for bows.

The earliest example of the use of gut that can be traced is one from the Badarian period, which is described as 'Thong of animal tissue, Gut.'[5] Then, in date order, comes a specimen from the Third Dynasty which was found in the step pyramid at Saqqara, and consists of two small twisted pieces, one about two inches (5 cm.) long, and the other about four inches (10 cm.) long, probably both originally part of the same piece, since they are of the same thickness, about 0.06 inch (1.5 mm).[6] After these comes a specimen of the Second Intermediate Period, which is described as 'finely twisted gut, which may have been a bowstring.'[7] The next examples are from the Eighteenth Dynasty and consist of (*a*) part of a bowstring attached to a bark-covered compound bow from Qurna[8]; (*b*) a number of twisted pieces of bowstring of different thicknesses, varying from about 0.06 inch (1.5 mm.) to about 0.14 inch (3.5 mm.), all from the tomb of Tut-ankhamun (one example of a linen bowstring was also found), and (*c*) portions of three twisted strings still on a lute found at Deir el Bahari.[9]

Hair

Human nature being fundamentally the same everywhere and at all periods, it is not surprising to find that the women of ancient Egypt, even as early as the First Dynasty at least, used artificial locks of human hair to supplement their own when these had become scanty by reason of old age, or because fashion required it. Human hair, too, was

[1] J. G. Wilkinson, *The Ancient Egyptians*, 1890, II, p. 54.

[2] A. E. P. Weigall, *A Guide to the Antiquities of Upper Egypt*, 1913, p. 126.

[3] Nina de G. Davies and Norman de G. Davies, *The Tombs of Menkheperrasonb Amenmose and Another*, Pl. IX.

[4] N. de G. Davies, *The Tomb of Puyemrê at Thebes*, I, pp. 87, 103.

[5] G. Brunton, *Mostagedda*, p. 60.

[6] Now in the Cairo Museum, No. J. 69524.

[7] G. Brunton, *op cit.*, p. 128.

[8] G. Daressy, *Recueil de travaux*, XX (1898), p. 73. Cairo Museum, No. J. 31389. The string apparently was complete when found. See also G. Brunton, *Annales du Service*, XXXVIII (1938), pp. 251–2.

[9] A. Lansing and W. C. Hayes, *Bull. Met. Mus. of Art, New York, Egyptian Exped., 1935–1936*, p. 8. Cairo Museum, J. 66248.

employed for making wigs, though these were also sometimes made of vegetable fibre, but there is no evidence of horsehair or wool having been employed for this purpose despite the statements in the literature to this effect.[1] I have made a microscopical examination of the fibre of all the wigs in the Cairo Museum (fifteen altogether), the results of the examination of fourteen of which have been published.[1]

Seven of these are large ceremonial wigs of the priests of the Twenty-first Dynasty; they are covered with a mass of small corkscrew curls and have long narrow plaits hanging down behind. Although they have been described as consisting of horsehair,[1] they are all of human hair of a brown or dark brown colour when cleaned, though appearing black before cleaning, and are stuffed (evidently for the sake of economy) with fibres from the reddish-brown fabric-like material that surrounds the base of the branches of the date palm.

A further wig, described as from the same source as the previous seven, is much smaller and consists of small light brown curls without any plaits and without stuffing. This, too, is human hair. Another mass of hair (undated), probably at one time a wig, is very similar, though darker in colour, and is also human hair.

Two other large wigs (undated) are very similar to the seven already mentioned, but without stuffing, and consist of dark brown human hair.

The wig of Queen Isimkheb (Twenty-first Dynasty), which has been described[1] as 'hair mixed with the wool of a black sheep' is of very large size and is covered with small curls and has long narrow plaits behind, but no stuffing: it consists entirely of human hair, mostly of a dark brown colour.

Yuya's ceremonial wig (Eighteenth Dynasty) which has been described as 'woollen,'[1] is similar to that of Queen Isimkheb and consists entirely of human hair of a very dark brown colour.

Two further wigs of small corkscrew curls on a plaited base, both probably of Roman date, consist of vegetable fibre, one being certainly date palm fibre and the other probably grass.

On all the hair wigs without exception and on one of the fibre wigs there is beeswax, some of which was removed by means of a solvent and identified by its properties, particularly by the melting point. The present drab colour of many of the curls and plaits is due to dust and

[1] For references see A. Lucas, *Ancient Egyptian Wigs, Annales du Service*, xxx (1930), pp. 190–6.

dirt that have adhered to the wax. As beeswax would be such an eminently suitable material to ensure the permanency of the curls and plaits there can be little doubt that it was for this purpose that it was employed and that its presence is not to be explained by any anointing, which would only be possible with a liquid oil, or a solid fat liquefied by heat before use, or one that became liquid at the temperature of the human body, or of the room where the wig was being worn. The melting point of beeswax, which is slightly more than 60°C. (140°F.), is much too high for it to have melted and flowed over the wig had it been applied in the solid form and, therefore, it is practically certain that it must have been warmed and rubbed into the hair.

Small plaited locks of hair sometimes were treasured in ancient Egypt, as is often done to-day, and such a lock was found in the tomb of Tut-ankhamun,[1] the hair being that of Queen Tiy, who was the grandmother of Tut-ankhamun's wife and from whom Tut-ankhamun himself was probably descended.

Brunton found three round balls of human hair in predynastic graves[2] and two lots of human hair in tombs of Seventh to Eighth Dynasty date, one of which latter was in the form of a small pad that had been used to apply a red powder, possibly to the face, and the other was associated with eye and face paint.[3]

Hair was occasionally employed for threading beads, examples being known for bracelets of predynastic[4] and First Dynasty[5] dates respectively. Another bracelet of the First Dynasty was in part composed of hair 'probably from tails of oxen.'[6] From the period Fourth to Tenth Dynasties there are bracelets of fibre and hair[7] and bracelets entirely of hair from 'Pan' graves.[7] The nature of the hair in these cases has not been determined. Beads of the Badarian period have been found strung on animal hair.[8] Various objects, too, were made of hair, such as the four from the tomb of Tut-ankhamun, which the finder calls fly-whisks.[9] These consist of bunches of long hair fixed in gilt wooden handles having the form of animals' heads, and they are possibly the objects so often shown hanging down at the sides of chariot horses and which are depicted on several pieces of the gold decoration belonging

[1] Howard Carter, *The Tomb of Tut-ankh-Amen*, III, p. 87.
[2] G. Brunton, *Mostagedda*, p. 90. [3] G. Brunton, *Gau and Badari I*, pp. 36, 55.
[4] G. Brunton, *Mostagedda*, p. 85.
[5] W. M. F. Petrie, *The Royal Tombs*, II, p. 19.
[6] W. M. F. Petrie, *op. cit.*, p. 18. [7] G. Brunton, *Mostagedda*, pp. 110, 130.
[8] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 57.
[9] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 224; Pl. XLIII (*c*).

to the harness from this tomb. As pointed out to me by Dr. H. H. Nelson, these objects must have been bundles of fibres, as sometimes they are given a wavy appearance to indicate that they are streaming with the wind. This hair is in so disintegrated a condition that although I examined it microscopically in the usual manner it was impossible to identify it with certainty, but it is probably either horsehair or donkey hair. Fly-whisks of giraffe-tail hair, possibly mixed with a little goat hair, were found by Reisner in the graves of the Middle Kingdom Egyptian colony at Kerma in the Sudan,[1] where there were also a number of armlets of giraffe-tail hair.[1] At Balabish Wainwright found a net bag of giraffe-tail or elephant-tail hair[2] and in Nubia Firth discovered an armlet of elephant-tail hair.[3] Brunton found a piece of woven-hair fabric, the hair possibly being goat hair, from the Ptolemaic or early Roman period[4] and hair matting of Roman or Coptic date.[5] Hair cords and a piece of very coarse hair cloth of the seventh century A.D. were found by Winlock at Thebes,[6] but the nature of the hair is not stated. A piece of camel-hair cord of Third or early Fourth Dynasty date is known.[7] Cloth made of goat hair is mentioned in 185 B.C.[8]

Horn

Horn was used in ancient Egypt from the earliest periods and objects made from this material have been found in graves. From predynastic times, bracelets,[9, 10] combs,[9] harpoon heads,[10] tags,[10] vases or cups[9] and a carved horn adapted for use as a receptacle[11] are known; from the First Dynasty bows[12] gaming pieces[13] and carved horn[12] and from later periods, miscellaneous objects, including what are possibly strigils[14];

[1] G. A. Reisner, *Excavations at Kerma*, IV–V, pp. 313–15.
[2] G. A. Wainwright, *Balabish*, pp. 12, 32, 46.
[3] C. M. Firth, *Arch. Survey of Nubia, Report for 1910–1911*, p. 84.
[4] G. Brunton, *Mostagedda*, p. 139.
[5] G. Brunton, *Mostagedda*, p. 145.
[6] H. E. Winlock and W. E. Crum, *The Monastery of Epiphanius at Thebes*, pp. 71–2.
[7] G. Caton-Thompson and E. Gardner, *The Desert Fayum*, pp. 88, 119, 123.
[8] A. S. Hunt and J. G. Smyly, *The Tebtunis Papyri*, III (Part 1), No. 796.
[9] W. M. F. Petrie, *Prehistoric Egypt*, pp. 30, 31, 40, 48.
[10] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 46–7.
[11] G. Brunton and G. Caton-Thompson, *op. cit.*, p. 60.
[12] (*a*) W. M. F. Petrie, *The Royal Tombs*, II, pp. 26, 38, 39: (*b*) L. Keimer, Bemerkungen zu altägyptischen Bogen aus Antilopenhörnern, *Zeit. f. ägyptische Sprache*. 72 (1936), pp. 121–8.
[13] W. B. Emery, *The Tomb of Hemaka*, p. 40.
[14] G. A. Wainwright, *Balabish*, pp. 13, 31, 49.

horns used as receptacles and horn handles for tools and weapons. Horn was also employed during the Eighteenth Dynasty as one of the components of compound bows.

IVORY

Ivory, both that from the elephant and that from the hippopotamus, was extensively employed in ancient Egypt from neolithic times[1] onwards, largely because it was dense and fine-grained and well adapted for carving, in which work the ancient Egyptians were very skilled. The use of elephant ivory at an early date, although it must mean that the elephant was well known, does not necessarily imply that it was then wild in Egypt, which was probably not so, but merely that being plentiful in the country immediately to the south of Egypt (the Sudan), a supply of ivory would be easily accessible. The hippopotamus, on the other hand, was still abundant in Egypt, even as late as several hundred years ago. According to the ancient records ivory was obtained from Negro Lands (Sixth Dynasty)[2]; Punt (Eighteenth Dynasty)[3]; God's Land (Eighteenth Dynasty)[4]; Genebteyew (Eighteenth Dynasty)[5]; Kush (Eighteenth Dynasty)[6] and the South Countries (Eighteenth Dynasty)[7] all of which were situated in Africa to the south of Egypt, but in addition also from Tehenu (Eighteenth Dynasty),[8] which, too, was in Africa, though to the west, and from Retenu (Eighteenth Dynasty)[9] and Isy (Eighteenth Dynasty),[10] both of which were in Asia. The ivory objects found in the tombs include anklets, arrow tips, boxes, bracelets, combs, cylinders (carved), dishes (shallow), figures (human and animal), hair pins, handles for knives, daggers, fans and whips, harpoon heads, inlay, legs for articles of furniture, mace heads, plaques, vases, veneer, and wands.

Carved ivory objects were sometimes artificially stained or painted, generally red, but occasionally very dark brown or black or very rarely green, the nature of which colours, however, it has not been possible to determine, except the red on some First Dynasty arrows, some of which and possibly all was red oxide of iron.[11, 12]

[1] H. Junker, *Merimde-Benisalâme*, 1929, p. 237; 1930, pp. 71–2.
[2] J. H. Breasted, *op. cit.*, I, 336.
[3] II, 263, 265, 272, 486.
[4] II, 265.
[5] II, 474.
[6] II, 494, 502, 514.
[7] II, 652.
[8] II, 321.
[9] II, 447, 509, 525.
[10] II, 493, 521.
[11] W. B. Emery, *The Tomb of Hemaka*, p. 47.
[12] R. Macramallah, *Un cimetière archaïque . . . à Saqqarah*, 1940, p. 15.

Leather

In a country such as Egypt where cattle, sheep and goats were domesticated as early as the neolithic period and where there were many wild animals that were hunted at a still earlier date, namely, during paleolithic times, it is only natural that animal skins should have been made use of as clothing, and, although they have not been found from either the paleolithic or the neolithic period, they have been frequently discovered in Tasian,[1] Badarian[2] and predynastic graves,[3] having been used both as clothing for the living and wrappings for the dead. From raw hide to skin treated sufficiently to render it pliable and thence to fully tanned leather are steps that the Egyptians took at a very early date, and articles of leather are common in Tasian,[1] Badarian[4] and predynastic tombs.[5] Leather working is depicted in a Twelfth Dynasty tomb at Beni Hasan,[6] in an Eighteenth Dynasty tomb at Thebes[7] and in a Twenty-sixth Dynasty tomb at Thebes.[8]

Leather was used for bags; braces (which were probably a priestly insignia in the Twenty-first and Twenty-second Dynasties); bracelets; cushion covers; chariot flooring and tyres; dagger sheaths; harness; quivers; ropes; sandals; dog collars; seats of chairs and stools; for writing upon, which was very common,[9] and for various other purposes. The largest piece of leather work that has survived is the funeral tent of Queen Isimkheb (Twenty-first Dynasty), now in the Cairo Museum. Leather appliqué work in colours and leather cut into fine network are known. Leather was frequently dyed, the colours being red, yellow or green. At what period leather dyeing was first practised is uncertain, but the red colour, which appears to have been used before either of the other two, is known from the Eleventh Dynasty[10] and also from ' pan ' graves.[11] The nature of the dyes has not been determined, but the red was possibly kermes and the yellow, pomegranate rind.

[1] G. Brunton, *Mostagedda*, pp. 5–7, 33.
[2] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 19, 40.
[3] W. M. F. Petrie, *Prehistoric Egypt*, p. 47.
[4] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 41.
[5] W. M. F. Petrie, *Prehistoric Egypt*, pp. 34, 43, 47.
[6] P. E. Newberry, *Beni Hasan*, I, Pl. XI; II, Pl. IV.
[7] P. E. Newberry, *The Life of Rekhmara*, Pls. XVII, XVIII.
[8] The tomb of Aba (No. 36) in the Asasif.
[9] J. H. Breasted, *op. cit.*, II, 392, footnote *a*.
[10] An object of red leather described as a ' tag from wrists ' of Eleventh Dynasty date from Deir el Bahari is in the Cairo Museum (No. J. 51874).
[11] G. A. Wainwright, *Balabish*, p. 26. G. Brunton, *Mostagedda*, p. 130.

Kermes, which consists of the red dried bodies of a female insect (*Coccus ilicis*), is one of the oldest dye substances known, and, as it is stated to be useless without a mordant, but gives a red colour with alum, it was probably used with an alum mordant. The kermes insect feeds on a particular kind of oak tree that grows in south-eastern Europe and in north Africa. This dye was used in Egypt in modern times for leather.

Pomegranate rind is sometimes employed in Egypt to-day for dyeing leather a yellow colour and possibly, therefore, it was used anciently, though its use seems unlikely before the Eighteenth Dynasty, the earliest date at which the tree, which is not a native of Egypt but of western Asia, is known in the country.[1] Wainwright states that most of the leather of 'pan'-grave date found at Balabish was cow hide, but that in one instance it was sheep skin.[2]

Specimens of ancient leather, varying in date from the Eighteenth Dynasty to about the Twenty-third Dynasty, were kindly examined for me by Dr. (now Sir) R. H. Pickard, F.R.S.,[3] and in several instances goat skin was identified, one example being from the seat of a stool from the tomb of Tut-ankhamun[4] and another being sandals from about the Twenty-second or Twenty-third Dynasty, whereas sandals from the tomb of Tut-ankhamun were possibly calf skin.[4]

The nature of the tanning materials used by the ancient Egyptians has never thoroughly been investigated, but Theophrastus (fourth to third century B.C.), after describing the acacia (probably *Acacia arabica*) as an Egyptian tree, goes on to say that the fruit is a pod, which 'the natives . . . use for tanning hides instead of gall,'[5] and Pliny (first century A.D.), probably copying from Theophrastus, states that the pods of an Egyptian thorn tree (probably *Acacia arabica*) were 'employed for the same purpose as galls in the preparation of leather.'[6] These pods contain about 30 per cent of tannin and are used in the Sudan at the present day for tanning purposes and are also exported, and, therefore, from theoretical considerations alone it is not at all unlikely that they were used for a similar purpose in ancient Egypt, which has recently

[1] V. Loret, *La Flore pharaonique*, 2nd edition (1892), pp. 76–7.

[2] G. A. Wainwright, *Balabish*, p. 26.

[3] At that time Director of the British Leather Manufacturers' Research Association.

[4] A. Lucas, App. II, p. 176, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

[5] *Enquiry into Plants*, IV, 2, 1; IV, 2, 8. [6] XIII, 9.

been proved by Bravo,[1] who has examined the material (skins, tanned leather, tools and tanning material) from the remains of a tannery of predynastic date found at Gebelein in Upper Egypt and now in the Turin Museum. The skins were goat skins, the leather was undoubtedly tanned and the tanning agent consisted of pods of the acacia (*Acacia arabica*) still containing 31.6 per cent of 'tans.' In the case of the specimens of leather, already mentioned, examined by Dr. Pickard, although special search was made for both vegetable and mineral tanning substances, the results were negative.

Mother of Pearl

Mother of pearl is the nacrous material lining the shells of the pearl oyster and pearl mussel and is of the same composition as pearl, namely, essentially calcium carbonate.

Mother of pearl seems to have been very little used in ancient Egypt north of Aswan, and, with the exception of the well-known large shells, many of which bear the cartouche of Sesostris I (Twelfth Dynasty),[2] only a few other examples of its use can be traced, these including small oblong strips of 'pan-grave' date for threading as bracelets[3]; a scarab of Eighteenth Dynasty date[4]; a pair of earrings of the Roman period[5] and an amulet on a Coptic necklace.[6] It was employed, however, to a greater extent in Nubia, where it has been found in graves from archaic times onwards, the objects made from it being chiefly bracelets, button-like objects, pendants and rings.

As mother of pearl may be obtained from the Red Sea, this was undoubtedly the source of the ancient supply.

Ostrich Egg-shell

There is abundant evidence, both textual and monumental, to show that at one time the ostrich was fairly plentiful in both the eastern

[1] G. A. Bravo, *Leather in Ancient Egypt*, in *Journal of the International Society of Leather Trades Chemists*, xvii (1933), pp. 436–7 (*Boll. Uff. R. Staz. Sperim. per l'Ind. delle Pelli, etc.*, 1933, p. 75).

[2] H. F. Winlock, *Pearl Shells of Se'n-Wosret* i, in *Studies presented to F. Ll. Griffith*, pp. 388–92.

[3] G. A. Wainwright, *Balabish*, p. 20; Pl. III, 13; W. M. F. Petrie, *Diospolis Parva*, p. 45.

[4] P. E. Newberry, *Scarab-shaped Seals*, p. 368.

[5] W. M. F. Petrie, *Objects of Daily Use*, p. 14; Pl. X (250–1).

[6] Cairo Museum, No. J. 57141.

and western deserts of Egypt, though it is now no longer found in the country.

Among the earliest objects of any kind from ancient Egypt are ostrich egg-shells (often broken) and small disk beads and pendants made from them. These beads are very common in the earlier periods (neolithic,[1, 2] Badarian[3] and predynastic[4]), though they occur at all times, except during the Eighteenth Dynasty, at the beginning of which they ceased abruptly, but they began to come in again during the Nineteenth Dynasty and were still made in the Twenty-second Dynasty.[5]

PARCHMENT

Parchment is prepared from the skins of animals by first removing the hair and then rubbing the skin smooth with some abrasive material, such as pumice stone. Modern parchment is made from the skins of sheep and goats, but only one identification of the kind of skin used anciently in Egypt for parchment can be traced, and this was gazelle skin.[6]

Parchment is known principally as a material for writing upon, but this was not its earliest use in ancient Egypt, which was for covering drum heads and the sounding boxes of other musical instruments, such as mandolins, lutes and tambourins, the earliest example of this use being possibly of Middle Kingdom date. The objects in the Cairo Museum comprise a lute of which the parchment is coloured pink, which the finders call leather,[7] and an almost rectangular-shaped tambourin, the cover of which the finders call rawhide.[8] Both these, which

[1] G. Caton-Thompson, *The Neolithic Industry of the Northern Fayum Desert*, in *Journal Royal Anthrop. Inst.*, LVI (1926), p. 312.

[2] G. Caton-Thompson and E. W. Gardner, *The Prehistoric Geography of Kharga Oasis*, in *The Geographical Journal*, LXXX (1932), p. 371.

[3] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 3, 28: G. Brunton, *Mostagedda*, p. 60.

[4] W. M. F. Petrie, *Prehistoric Egypt*, p. 43.

[5] G. A. Wainwright, *Balabish*, p. 22.

[6] B. Bruyère, *Les fouilles de Deir el Médineh* (1934–35), pp. 116–7; Figs. 53, 61. Cairo Museum, No. J. 63746.

[7] A. Lansing and W. C. Hayes, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1935–1936*, p. 8; Figs. 10, 11. Cairo Museum, No. J. 66248.

[8] A. Lansing and W. C. Hayes, *op. cit.*, p. 13; Fig. 24. Cairo Museum, No. 66246. The nature of the cover is now unrecognizable, owing to its having been unwisely soaked in water when it was removed from the frame, which was repaired in the Museum workshop, but fortunately I examined it before it was destroyed.

are from the Eighteenth Dynasty, were found by Lansing and Hayes in the Theban necropolis and in each case the cover is parchment. Bruyère found at Deir el Medineh, also of Eighteenth Dynasty date, a one-stringed instrument, which he calls a lute, but which is termed a mandolin in the Cairo Museum register, the cover of which is stated to be made of gazelle skin.[1] A drum with parchment ends found by Garstang at Beni Hasan is of uncertain date, though the finder thinks it may be from the Middle Kingdom.[2]

Tortoise-shell

Modern tortoise-shell consists of the epidermic plates of a small species of sea turtle, but in ancient times probably the plates of more than one kind of turtle and also of the land tortoise were used. A large turtle is found in the Nile, a sea turtle both on the Mediterranean and Red Sea coasts of Egypt and a small land tortoise in Sinai, and also in both the eastern[3] and western deserts and the remains of very large land tortoises of Eocene times have been found in the Fayum province.

Tortoise-shell was valued in Egypt from a very early date and a large number of the objects of this material have been found in graves, particularly in Nubia, among which may be mentioned part of a ring; bracelets; a dish; a comb; a sounding board of a harp[4]; a sounding board of a mandolin[5]; as also several complete shells[6, 7, 8] and parts of shells.[9] The objects range in date from Tasian and Badarian times onwards.

Marine and Fresh Water Shells[10]

Shells are very common in ancient Egyptian graves, especially in those of early date, and their use goes back to neolithic times. The

[1] B. Bruyère, *Les fouilles de Deir el Médineh* (1934–35), pp. 116–7; Figs. 53, 61. Cairo Museum, No. J. 63746.

[2] J. Garstang, *Burial Customs of Ancient Egypt*, pp. 121, 156; Fig. 155.

[3] W. H. Schoff, *The Periplus of the Erythræan Sea*, p. 22.

[4] British Museum, *A Guide to the Third and Fourth Egyptian Rooms*, 1904, p. 173.

[5] Eighteenth Dynasty. B. Bruyère, *Les fouilles de Deir el Médineh* (1934–35), Figs. 53, 61.

[6] The Earl of Carnarvon and H. Carter, *Five Years' Explorations at Thebes*, p. 76.

[7] Cl. Gaillard and G. Daressy, *La faune momifiée de l'antique Égypte*, p. 69.

[8] British Museum, *A Guide to the Fourth, Fifth and Sixth Egyptian Rooms*, 1922, p. 31.

[9] G. Brunton, *Mostagedda*, pp. 5, 24, 30, 57.

[10] For Bibliography see Dr. Edmond Dartevelle-Puissant, *Chronique d'Égypte*, No. 23, January 1937.

smaller kinds were used chiefly as amulets, pendants, and strung together to form necklaces and girdles, while the larger shells were employed as receptacles for eye paints and other pigments. The greater proportion of these shells were from the Red Sea, though shells from the Mediterranean, fresh water shells from the Nile and land shells[1] were also used.[1-10]

One kind of shell sometimes employed was dentalium, a marine mollusc having a white, narrow, tubular shell that occurs on the shores of the Red Sea,[11] which were occasionally threaded and used as beads. Although this has been reported from both Badarian[12] and predynastic times,[12] the finder now agrees that the material was wrongly identified by the expert consulted and that it is organ coral and not dentalium and the mistake is corrected in a later publication.[13] A small lot of dentalium shells, however, of unknown date, marked 'Mitraheneh' are in the store of the Cairo Museum. Dentalium has been found in mesolithic burials in Palestine.[14]

Shells were also cut to form beads, bracelets, and other objects.

[1] W. M. F. Petrie, *Six Temples at Thebes*, pp. 30–1.
[2] G. Caton-Thompson, *op. cit.*, p. 313.
[3] G. Brunton and G. Caton-Thompson, *op. cit.*, p. 38.
[4] G. Brunton, *Qau and Badari I*, p. 71; *Qau and Badari III*, p. 35.
[5] G. A. Wainwright, *op. cit.*, pp. 17–9.
[6] G. A. Reisner, *Excavations at Kerma*, IV–V, p. 319.
[7] D. Randall-MacIver and A. C. Mace, *El Amrah and Abydos*, p. 49.
[8] L. Lortet and Cl. Gaillard, *La faune momifiée de l'ancienne Égypte*, I, pp. 191–8; II, pp. 105–22, 307–25.
[9] Cl. Gaillard and G. Daressy, *op. cit.*, pp. 75–84.
[10] G. Brunton, *Mostagedda*, pp. 29, 52, 57, 107, 109, 126.
[11] T. Barron and W. F. Hume, *Top. and Geol. of the Eastern Desert of Egypt*, pp. 127, 137.
[12] G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 38, 56.
[13] G. Brunton, *Mostagedda*, p. 85.
[14] Dorothy A. E. Garrod, in *Man*, XXXI (1931), 159.

CHAPTER IV

BEADS

The use of beads in Egypt dates back to the neolithic period, that is from about 12,000 to 7,000 years ago. The earliest beads are in the form of small, natural objects, such as bone, pebbles, seeds, shells and teeth, which, if not occurring with holes in them, were perforated artificially. These beads were worn round the neck, arm, ankle, or waist.

Although the objects mentioned possibly were sometimes used merely as ornaments, they were more commonly worn as charms. Strictly, therefore, the earliest beads were pendants employed as amulets, but it was from these objects that artificially-shaped, or artificially-made beads were evolved. Blue beads are still common in Egypt as amulets on children, horses, donkeys, and even on motor-cars.

That beads were very highly prized in ancient Egypt is shown by the enormous numbers of them that have been found in graves of all periods: they were used by both sexes and were made of a great variety of materials, both natural and artificial, including bone, faience, blue frit, glass, glazed material (quartz and steatite), ivory, metal (gold, silver, electrum, copper), ostrich egg-shell, resin, stones (usually coloured), straw and wood (sometimes gilt).

Mrs. C. R. Williams says[1] 'Indeed, the elaboration of bead jewelry was one of the most prominent contributions of Egypt to the development of personal adornment in antiquity. Never was a people fonder of beads or more ingenious and skilful in combining them; compared with Egyptian bead jewelry, modern bead bags seem trivial, and even the present-day necklaces of better materials are usually of less interesting and less organized designs. It was in Egypt that the colorful combining and intricate threading of beads of precious materials reached a high art.'

Carter and Mace say[2] 'The Egyptians were passionately fond of beads, and it is by no means exceptional to find upon a single mummy

[1] C. R. Williams, *Gold and Silver Jewelry and Related Objects*, p. 9.
[2] Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I, p. 159.

an equipment consisting of a number of necklaces, two or three collars, a girdle or two, and a full set of bracelets and anklets. In such a case many thousands of beads will have been employed.' On three men of the Badarian period Brunton found 'masses of beads running round and round the waist.'[1]

In the Eighteenth Dynasty tomb of Tut-ankhamun there were thousands of beads of different kinds, calcite, carnelian, coloured faience, gold, green felspar, opaque coloured glass, lapis lazuli (a few only, mostly large), dark red resin (a few only, all large) and gilt wood. These were respectively on collars, necklaces, pectorals, bracelets, earrings, garments, a pair of small sandals, and three footstools.

A large amount of miscellaneous material has been published in a scattered form describing the methods employed anciently for making beads, which may usefully be quoted and is as follows:—

Stone Beads

In his description of the making of stone beads found at Kerma in the Sudan, where there was a Twelfth Dynasty Egyptian colony, Reisner[2] states that '. . . the natural crystals and pebbles were broken up by percussion. Suitable pieces were then roughly shaped by rolling between stones or by bruising . . . The shaped pieces were then smoothed by rubbing, a process which leaves flat places on the visually curving surface, a state which may be seen on many of the finished beads . . . Some of the small glazed crystal beads . . . appear never to have been smoothed at all, but while still in the roughly bruised form they were pierced and glazed. The polished beads were bored after smoothing and before polishing or glazing . . . The boring operation was undertaken either from one side . . . or from two opposite sides. Apparently if the hole begun on one side gave difficulties, owing to the drill working into a slanting position or being diverted, another boring was begun on the opposite side to meet the first hole. The drill-point usually had a diameter of 1–2 mm., allowing for a certain widening of the hole in the drilling, and must have had a length of not less than 14 mm. It has usually been assumed that such holes could be drilled with a copper drill or a hard vegetable stalk using wet emery powder, and this method would seem to have been used at Kerma. Under the number Su 277 is recorded a stick of what appears to be

[1] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 27–8.
[2] G. A. Reisner, *Kerma*, pp. 93–4.

emery, which has been rubbed, perhaps to obtain the emery powder used in such boring. Two bronze points were found . . . one of which was certainly a drill, and three others, possibly drills, two of them with wooden handles . . . It will be noticed that I assume the use of a bow-drill, which was well known to Egyptian craftsmen from the Early Dynastic Period. After the hole was bored, the bead was polished, and, if desired, glazed. The glazed beads usually have the glaze in the hole, and were therefore dipped in the mass, like the faience beads. As the holes were larger and the material glass-like, the glaze entered the holes, although it did not enter the holes of the faience beads.'

It is much to be regretted that the emery-like material found by Reisner was not analysed. It is stated frequently that emery was used as an abrasive in ancient Egypt, but this has never been proved, and is highly improbable. Unless emery occurs in the Sudan near Kerma, for which there is no evidence, it must have been imported, if used, from the Greek islands, since its occurrence in Egypt has never been confirmed, and importation from the Mediterranean to the Sudan is so improbable that it may be ruled out. Also, since fine quartz sand will abrade quartz, which was the hardest stone the Egyptians worked (except beryl at a late date, which could have been done with its own dust) and since quartz sand is very abundant in Egypt, there was no need for emery.[1]

At Hierakonpolis, near El Kab in Upper Egypt, 'an enormous number of exceedingly small pointed flint implements were found; and with them were many broken carnelian pebbles, some chipped in the form of rough beads, one or two of which showed signs of the commencement of the boring operations; also chips of amethyst and rock-crystal, and one or two flakes of greenish black obsidian. Other collections of these small flint points, and materials from which beads were made, were found . . . These flint points seem to be drills for boring carnelian, amethyst and other beads, but how this was accomplished is not evident.[2]

The most recent description of the methods of making stone beads is that of Myers in collaboration with Hart.[3] Myers points out that naturally 'The first process with all hard stone beads was to chip or flake them to rough shape.' The beads were then finished by 'rubbing down,' that is by rubbing them on a flat surface by hand; by 'groove-

[1] See p. 92.
[2] J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 12.
[3] Sir R. Mond and O. H Myers, *Cemeteries of Armant*, I, pp. 74–9.

grinding,' applied to cylinder beads, or possibly to several disc beads held together on an axis, which consisted in rubbing them ' in a suitable groove in a hard gritty stone, usually quartzite; or by ' turning,' which ' was probably done by attaching the bead to the end of the shaft of a drill, and then turning it in a wooden cup or recess (or against a flat surface) by rotating the shaft in the usual way, feeding it, of course, with an abrasive.' Myers suggests that the drill or boring tool, which he prefers to call a ' lap,'[1] was of flint, or copper (solid or tubular), and that the abrasive was probably the finely-ground chips from the beads themselves. In one instance, however, finely crushed flint or chert was found in a hole in a steatite bead.[2]

A lot of 152 rough spheroids of carnelian (undated) from Mit-rahineh in the Cairo Museum[3] manifestly are partly-made beads that have been roughed out from natural carnelian pebbles (which occur abundantly in Egypt), but which were never finished or bored. The diameters vary from about six to about twelve millimetres (approximately 0.23 to 0.47 inch).

In a number of tombs of Eighteenth Dynasty date in the Theban necropolis the drilling of beads by means of a bow-drill is shown,[4] and in a Sixth Dynasty tomb at Gebrawi the drilling of pieces of carnelian, not with a bow-drill, is shown.[5]

In the Cairo Museum there are a number of very tiny beads of Middle Kingdom date made respectively of carnelian, lapis lazuli and turquoise, which vary in diameter from about 0.58 to 0.64 millimetre (approximately 0.023 to 0.025 inch). Vernier gives the mean diameter of two lots of these beads as 0.70 to 0.77 millimetre (approximately 0.028 to 0.031 inch).[6] In what manner these beads were bored is not known. Tiny beads of much the same size have been found also in India and Mesopotamia.

Mackay recently found at Chanhu-daro in India a complete bead-

[1] In my opinion, this name is not very satisfactory, since a lap may be a lead plug carrying emery powder and oil, such as is used for polishing the interior of the barrels of firearms, or it may be a disc of metal rotated in a lathe.

[2] Sir R. Mond and O. H. Myers, *op. cit.*, p. 93.

[3] Museum No. J. 46778.

[4] P. E. Newberry, *The Life of Rekhmara*, p. 36; Pl. XVII: N. de G. Davies (*a*) *The Tomb of Two Sculptors at Thebes*, p. 63; Pl. XI; (*b*) *The Tomb of Puyemrê at Thebes*, p. 75; Pls. XXIII, XXVII; (*c*) *The Tomb of Two Officials of Tuthmosis the Fourth*, p. 11; Pl. X; (*d*) *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1918–1920*, p. 38; Fig. 9 (Tomb No. 75 at Thebes).

[5] N. de G. Davies, *The Rock Tombs of Deir el Gabrâwi*, I, p. 20; Pl. XIII.

[6] E. Vernier, *Bijoux et Orfèvreries*, Nos. 52825–52826.

maker's outfit, including the raw material in the form of agate and carnelian; chert drills and both finished and unfinished beads, all of which he describes in detail.[1]

Beck says[2] of certain Mesopotamian beads that ' The perforation was done with a hollow rotating drill. Another feature is that it was generally drilled straight through from one end, with the result that there is often a large chip where it broke through the second surface.'

Shell Beads

In addition to the natural marine and fresh water shells merely bored and strung together as beads, which have already been mentioned, the Egyptians also made small ring beads and disc beads from shells, and similar beads, too, from ostrich egg-shell, the form being imposed by the character of the material, and it is not always easy to distinguish between them. Such beads date back to the neolithic period. The method of making these beads is described by Reisner,[3] namely first, the shell was broken up into conveniently-sized pieces, which were roughly trimmed by crushing away the edges, possibly with a blade, then the hole was drilled from both sides with a blunt point, and finally the beads were smoothed on the edges, probably after stringing. During the Eighteenth Dynasty these disc beads went out of use completely and were replaced by similarly-shaped beads of faience, as for example in the tomb of Tut-ankhamun, in which, although there were many thousands of beads, there were none of shell. These beads, however, began to come into use again during the Nineteenth Dynasty and were still made in the Twenty-second Dynasty.

Faience Beads

In Egypt, faience beads date from the pre-dynastic period. With respect to the faience beads found at Kerma, Reisner states[4] that ' The greater part of the beads have straight smooth threading holes with little or no discoloration of the inner surfaces. Professor Petrie's conclusion that beads were made on threads which were burnt out in the

[1] E. Mackay, (*a*) Bead Making in Ancient Sind, *Journal of the American Oriental Society*, 57 (no date given, but probably 1937), pp. 1–15; (*b*) Excavations at Chanhu-daro, *Journal of the Royal Society of Arts*, LXXXV (1937), pp. 527–45; (*c*) *The Illustrated London News*, 14 November, 1936, p. 864.

[2] H. C. Beck, Notes on Glazed Stones. Part I., *Ancient Egypt and the East*, 1935, p. 26.

[3] G. A. Reisner, *Kerma*, p. 94.

[4] G. A. Reisner, *op. cit.*, pp. 91–2.

firing is doubtless correct; but whether the beads were made on a thread, or on some other axis, the method of forming the ring-beads, the disc-beads and the tubular beads, suggested first, I believe, by Professor Petrie, is the most obvious. The axis was coated with the body-paste to a depth of 1–5 mm., according to the size and type of the beads in hand, and perhaps rolled on a board. While still moist this long cylinder was cut with a knife into sections, short for the ring-beads and the disc-beads, and long for the tubular beads. These were then dried and baked without removing the axis. The barrel-shaped beads, the pendant-beads and the ball-beads were probably made in the same way by coating an axis and cutting the coat of paste into sections. These sections could then be modelled with the fingers to the desired forms and trimmed at the ends, that is around the axis, with a knife. The ends of the tubular beads have clearly been trimmed, and the slight flattening around the two ends of the hole on almost all ball-beads is without doubt also due to trimming with a knife. The amulet-beads could have been made on an axis in much the same way, but for them the paste-coating was thick and was made into a form with rectangular section. This could have been done very simply by pressing the coat of paste, while on the axis, against a board or other hard, flat surface. Thereafter the ends were trimmed and the details added with a knife.'

'Some of the larger ball-beads were not made on an axis but pierced. The best example was a broken faience bead . . . which had been pierced while the paste was still soft by thrusting with a slender point from one side and then from the opposite side. The instrument used may well have been a blunt-ended, stiff wire, or even a bone or bronze awl.'

'I have assumed . . . that the beads were fired the first time while still on the axis. This conclusion is deduced from the advantage of handling such small fragile objects while still on the axis, and from the slight scorching of the inside of the hole in some beads. Dipping was the only obviously practical method of applying the mixed blue-glazing solution. Although the glaze covers the ends of the beads without penetrating the threading-hole, it need not be concluded that the beads were restrung for dipping, as liquid does not readily penetrate such small holes. The glaze did penetrate the holes of the crystal beads, but these holes were larger in diameter and made in a glass-like material. The next step after the glaze was the second firing. It is to be noted that the ball-beads show a spot on one side where the glaze is imperfect, and the tubular beads show a line down one side, but no beads have contact marks at the ends around the threading holes. The contact

marks mentioned are most easily explained by the assumption that the beads were glazed in pans, or on the floor of the oven. Many beads, however, show no trace of contact marks whatever, and I am not sure how these were fired. Possibly the contact marks have been removed by rubbing. Certain lots of small ring-beads were found . . . in which the beads were gathered together in irregular clusters by the interfusing of the glaze. This condition leads to the conclusion that these particular beads were fired *en masse*, in the oven; but it is obvious that this method was not the usual one.'

' The tiny ring-beads appear in many cases to be nearly pure coloured glaze, but with a minute opaque or even whitish core. It is possible that for these beads the axis was coated either (*a*) with a very thin coat of paste, or (*b*) with a thick coat of coloured glazing mixture only and that the beads were then fired only once. But it is also possible that the very tiny ring-beads may have been made in the usual manner, and that owing to their small size the cores have been more highly affected by the heat than in the larger beads and may have been fused with the glaze during firing.'

Petrie states[1] that the faience beads from Naucratis ' were commonly made on a thread, dried and the thread burnt out; they were then dipped in glaze-wash and fired. In early times small beads were rolled between the thumb and finger on the thread, producing a long tapering form like a grain of corn.'

Beck describes methods of making faience beads,[2] and also various methods of decorating them.[3]

Glass Beads

Although it is sometimes stated that glass beads are known in Egypt from the predynastic period, this lacks confirmation, but they were made certainly from the Fifth Dynasty onwards.

Of the manner of making glass beads Petrie says[4] ' The usual mode of bead-making was by winding a thin thread of drawn-out glass around a wire. These wires are actually found with the beads still stuck on them . . . Many beads were imperfectly formed, and left as spirals owing to the tail of glass thread not being united to the body

[1] W. M. F. Petrie, *Arts and Crafts of Ancient Egypt*, p. 119.
[2] H. C. Beck, Report on Qau and Badarian Beads, *Qau and Badari II*, G. Brunton, pp. 22–5.
[3] H. C. Beck, *Classification and Nomenclature of Beads and Pendants*, pp. 69–70.
[4] W. M. F. Petrie, *Tell el Amarna*, p. 27.

of the bead. These are found of a corkscrew shape. . . . Some flat beads were made by coiling a long bead, flattening it and then cutting it across. . . . The pendant beads . . . show plainly the coils of the thread by which they were built up, in the clear structure of the glass. And every bead of this age shews more or less of the little peak at each end where the glass thread was finally separated from it. On the contrary the Coptic glass beads are all made by drawing out a glass tube, as shown by long bubbly striations; and then the tube was rolled under an edge across it, to nick it, so as to break it up into beads.'

Petrie also says[1] 'The early glass is all wound with lines running around; the Roman glass is all drawn out and nicked off with lines running along . . .' and[1] 'The thread of glass was wound round upon a hot copper wire of the size of the hole required: and after piling on enough, and completing the pattern of colour the wire contracted in cooling and could be withdrawn. The little point where the thread of glass broke off can be seen at each end of the beads.'

Beck describes[2] four principal ancient methods of making glass beads, most, if not all, of which were used in Egypt. These are as follows:

1. *Wire-wound Beads.* 'A thin stick of glass heated until it had much the consistency of toffee was wound round a wire. During the process the glass was pulled out into a thread, and there is frequently a projection on the bead showing where this thread was broken off. When, however, as often happens, the bead has been reheated for subsequent decoration, this projection generally disappears.' This method is the same as that described by Petrie.

2. *Cane Beads.* 'To make these the glass was made into a rod or tube which was called a cane. These canes were sometimes made of one glass only; at other times they were made of different coloured glasses arranged in a pattern.'

'To make a bead, a cane, usually tubular, was selected of approximately the same diameter as the bead required. A piece the length of the bead was cut off this cane. In some cases this was used as a bead without any further work on it. In other cases it was finished by either grinding or reheating.'

'The method of making tubular canes is of some interest . . . small glass tubes have been found . . . in the glass factory at Tel el Amarna . . . which . . . dates from the XVIIIth dynasty. By examining frag-

[1] W. M. F. Petrie, *Arts and Crafts of Ancient Egypt*, pp. 121, 125.

[2] H. C. Beck, *Classification and Nomenclature of Beads and Pendants*, pp. 60–9.

ments of these I have been able to trace the method of their manufacture. A strip of glass of considerable thickness, and wide enough to fold round a wire, was, whilst in a plastic condition, folded round and the edges fused together so as to make a tube. . . . These were sometimes reheated and pulled out into small tubular canes, such as those found at Tel el Amarna. . . . Pieces broken from these make long cylindrical beads, and a necklace entirely consisting of such beads simply broken off canes has been found in a New Kingdom grave at Abydos.' Petrie attributes cane beads to the Coptic period.

3. *Folded Beads.* 'When, however, the folded cane is not pulled out into a small tube, but beads are cut from it and ground to shape they are called *Folded beads.*' 'Folded beads were made in several other ways. One method was to prepare a slab of glass with a length nearly equal to the circumference of the required bead, and with a width approximately the length of the bead. This was folded round a rod and the two ends pressed together and fused. A slightly different way of making them was to prepare a strip of a similar form, and whilst it was plastic to press a rod through the centre of it perpendicularly to the face and then bend the two ends of the strip up so as to join together, enclosing the rod between them.'

4. *Double Strip Beads.* 'In this method two strips of glass were taken and placed on top of each other with a rod between them. They were then pressed together and cut off at the correct length to form the diameter of the bead, which was finished by rounding it to shape by pressure whilst the glass was still plastic.'

Beck describes also moulded glass beads and blown glass beads (which latter, however, were not made before the Roman period), and also various methods of decorating glass beads.

CHAPTER V

BUILDING MATERIALS

The nature of the building materials employed in any country depends upon many factors, the principal of which are the climate, the degree of civilization of the people and the kind of materials available.

Diodorus (first century A.D.) states[1] that 'They say the Egyptians in ancient times . . . made their houses of reeds, of which there are some marks amongst the shepherds at this day, who care for no other houses, but such like, which they say serves their turn well enough.' In Egypt, therefore, one may look back in imagination to a period when primitive shelters of dried reeds[2] were erected as a protection from the sun and wind, and one can imagine also the next stage of development when the reeds were plastered with clay in order to keep out the heat and cold more effectually. In two localities the remains of what probably were structures of this nature of predynastic date (in one case reeds plastered with clay[3] and in the other case twigs plastered with clay[4]) have been found.

At a later period the need of something more substantial than clay-plastered reeds or twigs manifestly was felt. The available suitable materials with which to make a more solid habitation were clay and stone, and, as suggested, clay probably had already been used to fortify the original reed shelters and, if so, its properties would have been familiar, whereas the knowledge and tools necessary for quarrying and dressing stone in quantity did not exist, and, therefore, clay, the known and more easily worked material, was chosen and was made into bricks, which were dried in the sun. The use of stone followed later when civilization had advanced sufficiently to provide metal (copper) tools.

Brick and stone will now be considered, as also the auxiliary materials required for building, namely, mortar, plaster and wood.

[1] I, 4.

[2] At the present day temporary shelters of maize stalks are common in the fields, maize, however, being a modern importation into Egypt.

[3] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 82–3.

[4] J. Garstang, *Mahâsna and Bêt Khallâf*, pp. 6–7.

Brick

Brick making is one of the oldest of the arts and was known to most of the nations of antiquity, but in few places has it been practised more than in Egypt, where sun-dried bricks still are, as they always have been, the characteristic building material of the country, and in the villages and smaller towns of Egypt the houses to-day are built of bricks similar to those that were used about 6,000 years ago.

The oldest bricks that have been found in Egypt are of pre-dynastic date, examples being at Naqada in Upper Egypt[1] and those lining two royal tombs at Abydos,[2] also in Upper Egypt. In tombs of First and Second Dynasty date at both Saqqara and Abydos bricks are very common and at Abydos, too, there is a ruined brick fort of the Second Dynasty the walls of which are still about 35 feet high.[3]

The bricks are made of Nile alluvium, or Nile mud as it is termed, of which all the cultivated land of Egypt consists and which is essentially a mixture of clay and sand, containing small amounts of impurities. The relative proportions of the two principal ingredients vary in different localities, and it is on the clay that the plastic and cohesive properties of the mud depend. When the percentage of clay is high, the mud is sufficiently tenacious to cohere without any extraneous binding material, though if the mixture is too rich in clay it is not satisfactory and bricks made from it not only dry slowly, but during drying, shrink, crack and lose their shape. In order to prevent this, such alluvium is mixed with sand, chopped straw or other material. Chopped straw also is sometimes added as a binder when the proportion of clay is low. The Egyptian practice of using straw in making bricks is mentioned in the Bible.[4] Chopped straw, however, and also animal (donkey) dung, which latter is employed occasionally, not only act as mechanical binders, but also increase both the strength and plasticity of the clay, especially if well mixed with it and allowed to remain some time before use.[5] Mellor states[6] that 'Clays which have been sodden with ground waters rich in organic matter are usually highly plastic,' and that humic acid, peat and other organic materials are added to clay to increase plasticity.

[1] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 54.
[2] W. M. F. Petrie, *A History of Egypt*, I (1923), pp. 4–5.
[3] W. M. F. Petrie, *Social Life in Ancient Egypt*, p. 151. [4] *Exodus*, v: 7–18.
[5] E. G. Acheson, *Journal Society of Chemical Industry*, XXIX (1910), p. 246; A. H. Drummond, *op. cit.*, XXXVIII (1919), p. 439 R.
[6] J. W. Mellor, *Inorganic and Theoretical Chemistry*, VI, p. 490.

The modern sun-dried bricks are made in wooden moulds and these moulds, as also the process in use, are practically identical with those employed anciently, as is shown by a mould of Twelfth Dynasty date found at Kahun[1]; by miniature moulds for funerary purposes, which also have been discovered,[2] and by a tomb-painting of the Eighteenth Dynasty in the Theban necropolis.[3, 4]

Since clay is plentiful and widely distributed in Egypt, and since sun-dried bricks do not require highly skilled labour, either for making or using, the houses constructed with them are cheap; also they are warm in winter and cool in summer and, although they would not stand the wet climate of Europe, they are very suitable for Egypt, where rain, except in the extreme north, is rare.

Old Egyptian bricks differ considerably in size, some being much the same dimensions as modern bricks, while others are very large, for example, two in the Cairo Museum each measure approximately 38 × 21 × 12 inches.

With the advent of stone, both tombs and temples, which previously had been built of sun-dried brick, began to be constructed of the newer material, but the houses, not only those of the poorer classes, but also those of the nobles and even the palaces of the Pharaohs, still continued to be made of brick, and it is for this reason that the houses and palaces have perished, while the tombs and temples remain, sun-dried brick being a much less enduring material than stone and also one that lends itself more readily than large blocks of stone to the building requirements of the modern inhabitants.

Burnt bricks, although used in Mesopotamia[5] and at Mohenjo-daro in India[6] at a very early date, were not employed generally in Egypt, so far as is known, before the time of the Roman occupation of the

[1] W. M. F. Petrie, *Kahun, Gurob and Hawara*, p. 26; Pl. IX.

[2] Carnarvon and Carter, *Five Years' Explorations at Thebes*, p. 31; Pl. XXII; Carter and Newberry, *The Tomb of Thoutmôsis IV*, pp. 3–4; J. E. Quibell, *The Tomb of Yuaa and Thuiu*, p. 61.

[3] P. E. Newberry, *The Life of Rekhmara*, p. 38; Pl. XXI.

[4] N. de G. Davies, *Paintings from the Tomb of Rekh-mi-rē at Thebes*, Pls. XVI, XVII.

[5] L. W. King, *A History of Sumer and Akkad*, pp. 3, 21, 22, 89, 91; L. Delaporte, *Mesopotamia*, pp. 175, 177; C. L. Woolley, *The Excavations at Ur, The Antiquaries Journal*, VII (1927), p. 387.

[6] Sir J. Marshall, *Mohenjo-daro and the Indus Civilization*, I, p. 15: E. J. H. Mackay, in (*a*) *Mohenjo-daro and the Indus Civilization*, p. 266, (*b*) Further Excavations at Mohenjo-daro, in *The Journal of the Royal Society of Arts*, LXXXII (1934), p. 212.

country. Petrie, however, mentions[1] several most unusual occurrences of burnt bricks for tombs and part of the foundations of a building at Nebesheh and Defenneh, of the Nineteenth and Twentieth Dynasties, though he says that Egyptian bricks 'were very rarely fired until the Roman age.'[2]

Stone

Egypt is the home of stone working and possesses both the oldest and largest stone buildings in the world. This activity in stone on a large scale and at so early a period was due partly to the fact of the country being very rich in stone and partly to the further fact that copper tools for working it were available. The earliest examples of the use of stone for building purposes that can be dated accurately are of the First Dynasty, namely, the lining and roofing with roughly cut slabs of limestone of a number of small chambers in a tomb of that date at Saqqara[3]; the limestone portcullis 'which shows a very high standard of the mason's craftmanship' in the First Dynasty tomb of Hemaka at Saqqara[4]; and a pavement of roughly dressed granite slabs in the tomb of Den (Udimu) at Abydos.[5] Also, 'A great deal of worked limestone in large slabs' found in the large First Dynasty mastaba of Senar at Tarkhan (about 45 miles south of Cairo),[6] and 'big limestone slabs carefully cut and well dressed' were used in a First Dynasty cemetery at Helwan.[7]

Less exactly dated, but certainly of the archaic period, are the natural blocks of undressed, or only roughly dressed, sandstone employed for walls, pavements, facing work and a tomb chamber at Hierakonpolis near Edfu in Upper Egypt[8] and the limestone lining and flooring of a protodynastic tomb near Gau, also in Upper Egypt.[9]

Of the Second Dynasty there are two inscribed limestone lintels from tombs at Saqqara[10]; a limestone room in the tomb of

[1] W. M. F. Petrie, *Nebesheh and Defenneh*, pp. 18, 19, 47.
[2] W. M. F. Petrie, *Egyptian Architecture*, p. 3.
[3] J. E. Quibell, *Excavations at Saqqara* (1912–14), pp. 3, 5.
[4] W. B. Emery, *The Tomb of Hemaka*, p. 6.
[5] W. M. F. Petrie, *The Royal Tombs*, II, pp. 9–10; Pl. LVIA.
[6] G. A. Wainwright, in *Tarkhan I and Memphis V*, W. M. F. Petrie, G. A. Wainwright and A. H. Gardiner, p. 15.
[7] Zaki Y. Said, *Annales du Service des Antiquités de l'Egypte*, XLI (1942), p. 408.
[8] J. E. Quibell and F. W. Green, *Hierakonpolis*, II, pp. 3–7, 14, 51.
[9] G. Brunton, *Gau and Badari I*, pp. 14–5.
[10] J. E. Quibell, *op. cit.*, p. 10.

Khasekhemui at Abydos,[1] an inscribed red granite door jamb[2] and fragments of a similar red granite door jamb or stela[3] from a temple of the same Pharaoh at Hierakonpolis.

Of the Second or Third Dynasty are the rough limestone slabs used for roofing and for portcullises in several tombs at Saqqara.[4]

In the Third Dynasty the increased use of stone for building is very marked, especially in Lower Egypt, where it culminates in the very fine buildings discovered a few years ago at Saqqara. Examples of stone work of this dynasty that may be mentioned are, in Upper Egypt, a limestone room in the tomb of Neter-Khet (Zoser) at Beit Khallaf, not far from Abydos,[5] the stone of which is stated to be 'carefully dressed,' and the limestone of the tomb of Hen-Nekht (Sa-Nekht)[5] and of three other tombs[5] also at Beit Khallaf. In Lower Egypt are the large blocks of granite in the unfinished pyramid at Zawyet el Aryan, between Giza and Abusir; the limestone of the pyramid of Zoser (the step pyramid) at Saqqara and its temenos wall; the adjoining limestone colonnade and temples; the granite chamber in the step pyramid and the granite chamber in the neighbouring great tomb,[6] all of which date from the early part of the dynasty.

An inscription on the Palermo stone states that a temple of stone was erected by an unknown king of the Second Dynasty, but the remains of this have not been found.[7]

From the examples given, it becomes almost certain that the use of stone for building purposes originated in Lower Egypt in connexion with the necropolis of Memphis[8] at Saqqara, where undoubtedly it was perfected, and since there were associations as early as the First Dynasty between Memphis and Abydos and in the Third Dynasty between Memphis and Beit Khallaf, the stone working in the south seems to have been merely a reflection of that from the north.

[1] W. M. F. Petrie, *op. cit.*, p. 13; Pl. LVII.

[2] J. E. Quibell and W. M. F. Petrie, *Hierakonpolis*, I, p. 6; Pl. II. This is in the Cairo Museum and is coarse-grained red granite and not grey granite as stated by the finders.

[3] A. Lansing, *Bull. Met. Museum of Art, New York, Egyptian Exped. 1934–1935*, Fig. 11, p. 44.

[4] J. E. Quibell, *op. cit.*, pp. 1, 3, 10, 15, 17, 29, 40, 41.

[5] J. Garstang, *Mahâsna and Bêt Khallâf*, pp. 3–15; Pls. VI, VII, XVII.

[6] (*a*) C. M. Firth, J. E. Quibell and J.-P. Lauer, *The Step Pyramid* (2 vols.); (*b*) J.-P. Lauer, *La Pyramide à degrés* (3 vols.).

[7] J. H. Breasted, *Ancient Records of Egypt*, I, 134.

[8] The name Memphis was not given to the city until the Sixth Dynasty (H. R. Hall, in *Cambridge Ancient History*, I, p. 273).

The principal kinds of stone employed for building in ancient Egypt were limestone, sandstone and, to a much less extent, granite with the occasional use of alabaster, basalt and quartzite, all of which may now be considered.

Limestone[1]

Limestone consists essentially of calcium carbonate (carbonate of lime), but contains varying, though usually small, proportions of other ingredients, such as silica, clay, oxide of iron and magnesium carbonate and it differs considerably in quality and hardness. It occurs extensively in Egypt, the hills bordering the Nile Valley from Cairo to a little beyond Esna, a distance of about 500 miles, being formed of this material and it occurs also sporadically from Esna to within a short distance of Aswan, for example on the west bank of the river at Faras near Silsila and on the east bank at Rangama near Kom Ombo; it is found also in other localities, as at Mex near Alexandria and in the neighbourhood of Suez.

Examples of the early use of limestone as a building material have been given already, and it continued to be employed for tombs and temples until about the middle of the Eighteenth Dynasty, when, though still occasionally used, as in the temples of Seti I[2] and Ramesses II[3] at Abydos, both of the Nineteenth Dynasty, it largely gave place to sandstone. In addition to the use of limestone as a building material, a very large number of tombs of all periods were cut out of the living limestone rock.

Although limestone was quarried generally in the immediate vicinity of where it was required, the better qualities were obtained from special localities, and such quarries often are referred to in the ancient records, for example, those at Tura (Troja),[4] Ma'sara,[5] Ayan (Tura-Ma'sara)[6] and Gebelein,[7] which may be seen to-day with the ancient inscriptions on the walls.

[1] See also p. 471.

[2] Most of the walls are of limestone, as also the pavement and portions of the pillars in the entrance courts, but two of the walls, most of the pillars and the roof are of sandstone.

[3] Sandstone, granite and alabaster were all employed, the sandstone for pillars, the granite for door-frames and the alabaster for the sanctuary.

[4] J. H. Breasted, *Ancient Records of Egypt*, v (Index), pp. 101, 154.

[5] J. H. Breasted, *op. cit.*, v (Index), pp. 87, 154.

[6] J. H. Breasted, *op. cit.*, v, pp. 73, 154.

[7] J. H. Breasted, *op. cit.*, v, pp. 78, 154.

At Tura the inscriptions date from the Twelfth Dynasty to the Thirtieth Dynasty,[1, 2, 3, 4, 5] but there are references on the monuments to the Tura quarries as early as the Fourth Dynasty and the stone was employed extensively at Saqqara from the Third Dynasty and at Giza from the Fourth Dynasty. In the Cairo Museum there is a letter on papyrus (No. 49623) of the Sixth Dynasty written by an officer in charge of certain Tura quarrymen. The quarries are still being worked on a large scale.

At Ma'sara the inscriptions range from the Eighteenth Dynasty to the Ptolemaic period.[3, 4, 5, 6, 7] The quarries are still productive. It has been found recently, when they were explored systematically and the old debris removed, that the ancient quarries are very much more extensive than it was thought. Several previously unknown inscriptions have been discovered.

At Gebelein the inscriptions are from the Nineteenth Dynasty to the Roman period.[8, 9] The quarries are not now worked.

Other limestone quarries in which there are ancient inscriptions also are known, thus at El Bersheh there are quarries in one of which is a cartouche of the Thirtieth Dynasty[10]; in a quarry at El Amarna there is a cartouche of the Eighteenth Dynasty[11]; on the west of the Nile opposite Luxor there are small quarries in which until comparatively recently, when they were destroyed, were three inscriptions, one of the Twenty-sixth Dynasty and two of Roman date[12]; at Abydos there are two ancient quarries, one to the south and the other to the north-west, in the former of which it is stated there are cartouches and in the latter, cut at one of the entrances, is a sacred eye; near the ancient

[1] J. H. Breasted, *op. cit.*, I, 739; II, 799, 875.

[2] W. M. F. Petrie, *A History of Egypt*, I (1923), p. 192; II (1924), p. 36; III (1918), pp. 166, 375, 385.

[3] S. Birch, *Tablets found in the Quarries at Turah and Massara*, in *The Pyramids of Gizeh*, H. Vyse, III, pp. 93–103.

[4] G. Daressy, *Inscriptions des carrières de Tourah et Mâsarah*, in *Annales du Service*, XI (1911), pp. 257–68.

[5] W. Spiegelberg, *Die demotischen Inschriften der Steinbrüche von Tura und Ma'sara*, in *Annales du Service*, VI (1905), pp. 219–33.

[6] J. H. Breasted, *op. cit.*, II, 26.

[7] W. M. F. Petrie, *op. cit.*, III, p. 375.

[8] J. H. Breasted, *op. cit.*, III, 209; IV, 627.

[9] G. Daressy, *Les carrières de Gebelein et le roi Smendes*, in *Recueil de travaux*, X (1888), pp. 133–8.

[10] G. W. Fraser, in *El Bersheh*, P. E. Newberry, II, p. 56.

[11] W. M. F. Petrie, *Tell el-Amarna*, p. 4.

[12] W. M. F. Petrie, *Qurneh*, p. 15.

Ptolemais there are quarries of fine-grained limestone in which are inscriptions dating from the end of the Thirtieth Dynasty to the early part of the Roman imperial epoch[1]; at Gau (Antaeopolis) there are extensive quarries, some of which have a brick causeway leading to them, the bricks of which are stamped with the cartouche[2] of Amenophis II (Eighteenth Dynasty). In one of the quarries there is 'a crude painting of the Romanized local deity Antaios . . .'[2] and at Beni Hasan ancient quarries extend for at least three miles along the cliffs.[3]

As an example of stone having been quarried on the spot where it was required, that for the Giza pyramids may be mentioned. The stone of which the greater part of these pyramids is built is very characteristic, being highly fossiliferous and containing innumerable nummulites, and is identical with that of the plateau on which the pyramids stand and several of the large depressions near-by are the quarries from which this stone was obtained, although being now partly buried in sand they are not easily recognizable, the hollow in which the sphinx is, for example, being one of the quarries. It should be mentioned that many years ago (in 1883) Petrie denied this and stated,[4] 'But no quarryings exist on the western side in the least adequate to yield the bulk of either of the greater Pyramids; and the limestone of the western hills is different in its character to that of the Pyramid masonry, which resembles the qualities usually quarried on the eastern shore. It seems, therefore, that the whole of the stones were quarried in the cliffs of Turra and Masara and brought across to the selected site.' As Petrie wrote before any of the quarries had been uncovered it is not strange that they should have been overlooked, but it is singular that no mention is made of the very large amount of stone that was removed anciently in levelling the foundation plateau and in cutting back the rock on the north and west sides of the pyramid of Chephren, which stone almost certainly was used in the construction of the pyramid and would have formed a not inconsiderable proportion of the whole quantity employed. Of the Mycerinus quarry Reisner says[5] '. . . the quarry south-east of the Third Pyramid, which is nearly

[1] J. de Morgan, U. Bouriant et G. Legrain, *Note sur les carrières antiques de Ptolémais*, in *Mém. de la Mission arch. française au Caire*, VIII (1892), pp. 353–79.

[2] W. M. F. Petrie, *Antæopolis*, pp. 15, 16.

[3] Somers Clarke and R. Engelbach, *Ancient Egyptian Masonry*, p. 15.

[4] W. M. F. Petrie, *The Pyramids and Temples of Gizeh*, p. 209.

[5] G. A. Reisner, *Mycerinus*, p. 69.

of sufficient size to have supplied the whole ' that is ' the core of the pyramid, the foundation platforms of the temples and the massive core walls,' which ' were all of this stone ' (i.e. the local nummulitic limestone).

The casing stones of the two larger pyramids, those of Cheops and Chephren, and the casing stone of the upper portion of the third pyramid, that of Mycerinus, although limestone, was of a different and much finer-grained quality than the rest of the stone and free from fossils, as may be seen from the few blocks that remain, and, as this stone does not occur in the immediate neighbourhood, it must have been brought from elsewhere and almost certainly from the Tura quarries on the opposite side of the river, and the statements of Herodotus,[1] Diodorus,[2] Strabo[3] and Pliny[4] that the stone for the construction of the pyramids was brought across the river from quarries in the Arabian hills is true only of that for the casing. At that time, however, the casing of the first and second pyramids was intact and all that could have been seen was the Tura stone on the outside and there would have been no indication that the stone underneath was different. The step pyramid of Saqqara, too, is built of stone quarried on the spot and was cased with a better quality of stone, probably also from Tura.

The Old Kingdom tombs and temples, for which limestone was employed, were situated mostly in the neighbourhood of the capital, Memphis, where limestone of good quality, suitable for building, carving and painting upon, was plentiful, whereas when building on a large scale shifted south in the Eighteenth and following Dynasties, immense quantities of stone were required, at first in the vicinity of Thebes, which had succeeded Memphis as the capital, and later at places still farther south.

Although limestone occurs abundantly near Thebes, it is mostly of poor quality and ill-adapted for building purposes. To this there are two exceptions, already mentioned, namely, a little north of Elwat el Debban, near the Valley of the Tombs of the Kings, on the west of the Nile opposite Luxor and at Gebelein, almost midway between Luxor and Esna, in both of which places there is a comparatively small amount of better quality stone that was worked anciently.

In consequence, therefore, of the great scarcity of good quality limestone near Thebes, when building stone was required in large quantities, the choice was between transporting limestone from a

[1] II: 8, 124. [2] I: 5. [3] XVII: 1, 34. [4] XXXVI: 17.

distance or employing a substitute. Whether the first of the alternatives was ever adopted is uncertain, but the fine-grained limestone of the walls of the mortuary temple of Mentuhotep at Deir el Bahari and that of the temple of Amenophis I at Karnak appears too good a quality to be local. At Abydos, too, the limestone used in the temples of Seti I and Ramesses II respectively, which is of a particularly good quality, may not be local, although there are two ancient quarries of fairly good stone in the neighbourhood.

Sandstone[1]

Sandstone consists essentially of quartz sand derived from the disintegration of older rocks, cemented together by very small proportions of clay, calcium carbonate, oxide of iron or silica.

As already mentioned, the hills bordering the Nile valley from Cairo to near Esna are of limestone, but beyond Esna this limestone is replaced by sandstone, which in turn forms the hills on both sides of the river until near Aswan and again beyond Aswan from Kalabsha to Wadi Halfa.[2] The most northerly occurrence of sandstone is near Sabaia, between Esna and Mahamid. Sandstone also occurs at Aswan.[3]

Although not employed generally until about the middle of the Eighteenth Dynasty, sandstone was not an entirely new and untried material, as already it had been used on a small scale in the form of natural blocks of undressed or only roughly dressed material at Hierakonpolis as early as the archaic period[4] and it was employed also in the Eleventh Dynasty for the foundations, pavements, pillars, architraves, roof slabs and the walls in the hypostyle hall in the mortuary temple of Mentuhotep at Deir el Bahari.[5] The use of sandstone on a large scale, however, began about the middle of the Eighteenth Dynasty and practically all the existing temples in Upper Egypt are of this material, for example, the following-named (the earliest of which dates from the Eighteenth Dynasty and the latest from the Roman period), Luxor,[6]

[1] See p. 477.

[2] From Aswan to Kalabsha, a distance of about 40 miles, the hills are of granite and other igneous rock.

[3] J. Ball, *The First or Aswan Cataract of the Nile*, pp. 65–6.

[4] See p. 64.

[5] Somers Clarke, in *Deir el Bahari*, II, E. Naville, pp. 13–4.

[6] An inscription in the limestone quarry of Gebelein states that in the reign of Nesubenebded (Smendes) of the Twenty-first Dynasty stone from the quarry was employed to repair a wall round the Luxor temple (J. H. Breasted, *op. cit.*, IV, 627).

Karnak, Qurna,[1] the Ramesseum,[2] Medinet Habu, Deir el Medina, Dendera, Esna, Edfu, Kom Ombo, Philae, those in Nubia (i.e. between Aswan and Wadi Halfa) and those in the oases of the western desert.

The exceptions to the general use of sandstone are the mortuary temple of Hatshepsut at Deir el Bahari (Eighteenth Dynasty) and the temples of Seti I and Ramesses II respectively at Abydos (Nineteenth Dynasty), the first being almost entirely of limestone[3] and the other two containing much limestone. The Cenotaph of Seti I (the Osireion) at Abydos is built largely of sandstone with an outer casing of limestone and granite pillars and architraves.[4]

In addition, however, to the exceptions just mentioned, other temples in Upper Egypt, of which now only a few remains exist, were built in part of limestone, as for instance the mortuary temple of Amenophis I[5] (early Eighteenth Dynasty) on the west of the Nile opposite Luxor; the temple of the same pharaoh at Karnak; the temple of Tuthmosis III[6] (middle Eighteenth Dynasty) situated to the north-east of the Ramesseum; the temple of Amenophis II[7] (middle Eighteenth Dynasty) between that of Tuthmosis III and the Ramesseum; the temple of Tuthmosis IV[7] (latter part of Eighteenth Dynasty) to the south-east of the Ramesseum and the temple of Meneptah[6] (Nineteenth Dynasty) almost midway between the Ramesseum and Medinet Habu.

The principal ancient sandstone quarries were at Silsila, which is situated on the Nile about forty miles north of Aswan between Edfu and Kom Ombo. The quarries, which are very extensive, bear inscriptions dating from the Eighteenth Dynasty down to Greek and Roman times.[8, 9, 10] It seems probable that the earliest inscriptions, namely

[1] Limestone was used for the bottom courses of several walls and in a few other places. An inscription in the limestone quarry of Gebelein states that in the reign of Seti I stone from the quarry was employed in Seti's mortuary temple at Qurna (J. H. Breasted, *op. cit.*, III, 209).

[2] Limestone was employed for the columns in a side hall and for part of the pavement.

[3] A number of architraves in the north colonnade of the middle terrace are of sandstone, which is also present in the foundations of the two lower colonnades and of the south-west supporting wall.

[4] E. Naville, Excavations at Abydos, *Journal of Egyptian Archaeology*, I (1914), pp. 160–5; H. Frankfort, *The Cenotaph of Seti I at Abydos*, pp. 3, 10, 11, 14–8, 21, 241.

[5] Sandstone was also employed, but probably only for later additions.

[6] A considerable amount of sandstone was also employed.

[7] Probably largely sandstone.

[8] A. E. P. Weigall, *A Guide to the Antiquities of Upper Egypt*, 1913, pp. 358–60.

[9] J. H. Breasted, *op. cit.*, II, 348, 932; III, 205, 552, 627; IV, 18, 702.

[10] W. M. F. Petrie, *A History of Egypt*, III (1918), pp. 8, 119, 143, 144.

those of the Eighteenth Dynasty, represent the date when the quarry was first exploited, since the sandstone of the Eleventh Dynasty temple at Deir el Bahari (the principal example of the earlier use of sandstone), judging from its colour and texture, was not from these quarries. Its place of origin, however, is unknown, though suggestions have been made that it was from Aswan,[1] but though sandstone occurs at Aswan,[2] I have not been able to find there the particular quality used in the Mentuhotep temple.

Other ancient sandstone quarries are at Sirag[3] about twenty miles south of Edfu and at Qirtas, in Nubia, about twenty-five miles south of Aswan, which latter as shown by inscriptions in the quarry, was worked from about the Thirtieth Dynasty until Roman times, chiefly for the stone used in the construction of the temples at Qirtas and the temples of Philae.[4, 5].

At El Kab much of the sandstone employed for the temples was quarried in the neighbouring hills and is of very poor quality, but that used in the temple of Tuthmosis III is better and was possibly obtained from elsewhere.[6]

The stone for the temples of Nubia was quarried in the immediate vicinity of where it was required, and there are small ancient quarries at Dabod,[7] Tafa[8] and Beit el Wali.[9]

Granite.[10]

Granite is the name of a large class of crystalline rocks of igneous origin, that are not homogeneous in structure like limestone and sandstone, but are composed of a number of different minerals, chiefly quartz, felspar and biotite mica, but also sometimes hornblende and occasionally augite, the abundance of the quartz constituting one of the characteristic features of granite. The principal individual minerals readily being visible to the naked eye, the rock has a granular structure, from which its name is derived.

Granite was employed for building from the early dynastic period onwards, generally as a lining material for chambers and passages and

[1] Somers Clarke, *op. cit.*, p. 14.
[2] J. Ball, *The First or Aswan Cataract of the Nile*, pp. 65–6.
[3] W. F. Hume, *Explan. Notes to the Geol. Map of Egypt*, p. 47.
[4] J. L. Burckhardt, *Travels in Nubia*, pp. 113–16.
[5] A. E. P. Weigall, *op. cit.*, pp. 496–7.
[6] Somers Clarke, *El Kâb and its Temples*, in *Journal of Egyptian Archæology*, VIII (1922), pp. 20, 24, 29.
[7] A. E. P. Weigall, *op. cit.*, p. 492.
[8] A. E. P. Weigall, *op cit.*, p. 501.
[9] A. E. P. Weigall, *op. cit.*, p. 510.
[10] See p. 469.

for door-frames. Examples of its early use have been mentioned already,[1] but to these may be added its employment in the interior of the three large pyramids at Giza; for facing part at least of the lowest course of the pyramid of Chephren[2]; for facing the greater part (about two-thirds) of the pyramid of Mycerinus, where a considerable portion is still in position; in the interior of the pyramid temples of both Chephren and Mycerinus and for the construction of the small temple near the sphinx (valley temple of Chephren), all of which are of Fourth Dynasty date. Examples of its later use are certain door-frames in many of the temples of Upper Egypt.

The use of granite in the pyramid of Chephren is referred to by Herodotus, who says 'the lowest layer of it is of variegated Ethiopian stone'[3] and the granite facing of the pyramid of Mycerinus is mentioned by several of the classical writers, thus Herodotus states that 'as far as the half of its height it is of Ethiopian stone'[4]; Diodorus says, 'The walls for fifteen stories high were of black marble like that of Thebes, the rest was of the same stone with the other pyramids'[5]; Strabo writes that, 'from the foundation nearly as far as the middle, it is built of black stone . . . which is brought from a great distance; for it comes from the mountains of Ethiopia, and being hard and difficult to be worked, the labour is attended with great expense'[6] and Pliny states that 'it is built of Ethiopian stone.'[7]

In most instances the granite used anciently for all purposes was the coarse-grained red variety from Aswan, but grey granite (generally very dark grey, also from Aswan) was employed as well, though only to a comparatively small extent. Thus, in the First Dynasty tomb already mentioned, there is grey granite mixed with the red[8]; but the Second Dynasty temple door jamb from Hierakonpolis stated by the finder to be grey granite is coarse-grained red granite. Judging from the fragments of dark grey granite that lie about the ruins of the pyramid temple of Chephren this stone was employed in its construction and a few blocks of dark granite are present in Chephren's valley temple; among the red granite of the pyramid of Mycerinus, both outside and

[1] See pp. 64–5.

[2] H. Vyse (*The Pyramids of Gizeh*, II, p. 115) says 'The two lower tiers, about seven or eight feet in height, have facings of granite as Herodotus has truly described.' W. M. F. Petrie (*The Pyramids and Temples of Gizeh*, p. 96) states 'I have seen but one course; Vyse reports finding two courses.' I also have been able to find only one course.

[3] II, 127. [4] II, 134. [5] I, 5. [6] XVII, I, 33. [7] XXXVI, 17.

[8] W. M. F. Petrie, *The Royal Tombs*, II, p. 10.

inside, there is an occasional block that is dark grey and in the temple adjoining this pyramid there is a considerable amount of both red granite and dark grey granite; dark grey granite, as well as red granite, was employed also for door-frames in some of the Upper Egyptian temples and in the Cenotaph of Seti I at Abydos. Although for Egyptological purposes it is sufficient to call this grey stone 'dark grey granite,' strictly it is a hornblende-biotite granite. The *syenites* of Pliny, a name first used by this writer to describe a rock quarried at Syene[1] (the ancient name for Aswan), which stone he states was employed for certain columns in the Egyptian Labyrinth,[2] almost certainly was the ordinary Aswan red granite, as Pliny explains that *syenites* had formerly been called *pyrrhopœcilon* (i.e. spotted with red). The term syenite is now, however, applied to a granitic rock, resembling in appearance dark grey granite, in which mica is partly replaced by hornblende (which gives a dark colour to the stone) and in which quartz is absent or present only in small proportion.

Granite is widely distributed in Egypt and occurs plentifully at Aswan, in the eastern desert and in Sinai and to a small extent in the western desert.

The principal ancient granite quarries are at Aswan in two localities, one about a kilometre south of the town and the other on the east side of the plateau, but other and smaller quarries also exist on the islands of Elephantine and Sehel and in a few other places.[3] Quarries at Aswan,[4] Elephantine[5] and at the First Cataract[6] are all referred to in the ancient records as early as the Sixth Dynasty, also a quarry at Ibhet,[7] which has not been identified. The use of granite for building and other purposes is mentioned constantly.

In addition to the granite of Aswan and neighbourhood, the only other granites known to have been worked anciently are the red granite of Wadi el Fawakhir[8] (a continuation of Wadi Hammamat), between Qena and Quseir, the date of the working of which is unknown, but probably late (Weigall says Roman)[9] and the black and white granite quarried for export by the Romans at Mons Claudianus in the eastern desert.[10]

[1] XXXVI, 13. [2] XXXVI, 19.
[3] J. Ball, *A Description of the First or Aswan Cataract of the Nile*, 1907, p. 74.
[4] J. H. Breasted, *op. cit.*, I, 42. [5] I, 322. [6] I, 324. [7] I, 321, 322.
[8] T. Barron and W. F. Hume, *The Topog. and Geol. of the Eastern Desert of Egypt, Central Portion*, pp. 49, 118, 119, 265.
[9] A. E. P. Weigall, *Travels in the Upper Egyptian Deserts*, p. 50.
[10] W. F. Hume, *The Geology of Egypt*, II, Part II, pp. 380–5.

Alabaster[1]

Ordinarily alabaster means calcium sulphate (gypsum), but the material employed so extensively in ancient Egypt, which also is called alabaster, and which probably has the prior claim to the name, is an entirely distinct material of very similar appearance, but different chemical composition and consists of calcium carbonate. Geologically, Egyptian alabaster is calcite, though sometimes erroneously called aragonite, which is of the same composition, but of different crystalline form and different specific gravity. Whether aragonite is found in Egypt is not known, but its occurrence has not been reported and all the alabaster examined by me has been calcite.

The name alabaster, therefore, will be used in the present book as always meaning calcite, a compact crystalline form of calcium carbonate, white or yellowish white in colour, translucent in thin sections and frequently banded.

Alabaster was employed as a subsidiary building material chiefly for lining passages and rooms, particularly shrines, from early dynastic times to at least as late as the Nineteenth Dynasty, for example, possibly for a chamber in the step pyramid at Saqqara[2] (Third Dynasty); for a chamber in the valley temple of Chephren (Fourth Dynasty), judging from the blocks lying about, in the pyramid temple of Chephren; for the pavements of a corridor, a large court and a passage respectively in the pyramid temple of Unas at Saqqara[3] (Fifth Dynasty); for the pavement of the central part of the pyramid temple of Teti at Saqqara (Sixth Dynasty)[4]; for the sanctuary of a temple of Sesostris I[5] at Karnak (Twelfth Dynasty); for the sanctuaries of the temples of Amenophis I,[5, 6, 7, 8] Amenophis II[9] and Tuthmosis IV[5, 10] respectively (all Eighteenth Dynasty and at Karnak); for lining a corridor leading to the sacred lake at Karnak (Eighteenth Dynasty) and for the sanctuary of the temple of Ramesses II at Abydos (Nineteenth Dynasty).

[1] See p. 463.
[2] C. M. Firth, *Annales du Service*, xxv (1925), pp. 153–4.
[3] C. M. Firth, *op. cit.*, xxx (1930), p. 186.
[4] J. E. Quibell, *Excavations at Saqqara* (1907–8), p. 19.
[5] H. Chevrier, *Annales du Service*, xxviii (1928), p. 120.
[6] H. Chevrier, *op. cit.*, xxii (1922), pp. 238–40.
[7] H. Chevrier, *op. cit.*, xxiii (1923), p. 112.
[8] H. Chevrier, *op. cit.*, xxiv (1924), p. 56.
[9] H. Chevrier, *op. cit.*, xxiv, 57.
[10] H. Chevrier, *op. cit.*, xxiv, 59–60.

Alabaster occurs in Sinai,[1] where, however, there is not any evidence of its ever having been worked, and in various localities in the desert on the east side of the Nile. Beginning with the most northerly of these occurrences and proceeding southwards they are situated respectively as follows, (*a*) in the Wadi Gerrawi near Helwan, where there is a quarry dating from the Old Kingdom[2]; (*b*) in the Cairo-Suez desert, where the stone was worked for a short period in modern times, but where there is no evidence of ancient working[3]; (*c*) in the Wadi Moathil (a branch of the Wadi Sennur), almost due east of Maghagha, where there are not any signs of ancient working, but where there was extensive quarrying in the time of Mohammed Ali[1, 5, 6, 7]; (*d*) in the district extending from about Minia to a little south of Asiut, a distance of nearly ninety miles, where there are signs of working in many places and where the most important of the ancient quarries are situated. These, which are referred to frequently anciently, are at Hatnub, about fifteen miles east of El Amarna, and in them are inscriptions beginning in the Third Dynasty and continuing until the Twentieth Dynasty.[8, 9, 10, 11, 12] In one small alabaster quarry near El Amarna there are inscriptions of the Nineteenth Dynasty[11] and in another a rude relief, probably of Roman age.[12] A quarry, also in the same district, but farther south, situated in the Wadi Asiut, was worked at the beginning of the Eighteenth Dynasty and was reopened in the time of Mohammed Ali.[5, 13, 14, 15]

[1] H. J. L. Beadnell, *The Wilderness of Sinai*, p. 83.
[2] W. M. F. Petrie and E. Mackay, *Heliopolis, Kafr Ammar and Shurafa*, pp. 38–9.
[3] T. Barron, *The Topog. and Geol. of the District between Cairo and Suez*, pp. 20, 93.
[4] W. F. Hume, *Explan Notes to the Geological Map of Egypt*, p. 46.
[5] Dr. Hasan Sadek, Controller, Mines and Quarries Department, Egypt.
[6] R. Fourtau, *Voyage dans la partie septentrionale du Désert Arabique*, in *Bull. Soc. khéd. géogr.*, Cairo, 1900, p. 548.
[7] R. F. Burton, *The Gold Mines of Midian*, 1878, p. 89.
[8] J. H. Breasted, *op. cit.*, I, 7, 305, 690.
[9] G. W. Fraser, *Hatnub*, in *Proc. Soc. Bibl. Arch.*, XVI (1893–94), pp. 73–82.
[10] W. M. F. Petrie, *A History of Egypt*, I (1923), pp. 45, 56, 100, 102, 114, 125, 161.
[11] W. M. F. Petrie, *Tell el Amarna*, pp. 3–4.
[12] P. Timme, *Tell El Amarna*, 1917, pp. 45–7.
[13] A. E. P. Weigall, *The Alabaster Quarries of Wady Assiout*, in *Annales du Service*, XI (1911), p. 176.
[14] W. F. Hume, *The Alabaster Quarry of Wâdî Asiut*, in *Cairo Scientific Journal*, VI (1912), p. 72.
[15] R. Lepsius, 1853, *Discoveries in Egypt, Ethiopia and the Peninsula of Sinai in the Years 1842–1845*, pp. 112–3.

A white translucent alabaster occurs in small amounts and is worked on a small scale for vases (often sold as ancient ones) about three miles behind Wadiyein which branches off Wadi el Muluk, on the west side of the Nile opposite Luxor. There is no evidence of ancient working.

Egyptian alabaster was known to Theophrastus (fourth to third century B.C.), Pliny (first century A.D.) and Athenaeus (second to third century A.D). Theophrastus states[1] that alabaster was found in Egypt in the neighbourhood of Thebes, where it was dug up in large masses; Pliny writes in one place[2] that alabaster was found in the vicinity of Thebes and in another place[3] that it was obtained from Alabastron, the position of which he refers to elsewhere[4] in a very confused manner; thus after mentioning the mountains that form 'the boundaries of the province of Thebais' he says, 'On passing these we come to the towns of Mercury (i.e. probably Hermopolis), Alabastron, the town of Dogs and that of Hercules. . . .' If Alabastron were anywhere near Hermopolis it cannot have been far from Hatnub and these quarries, therefore, may have been known by repute to Pliny. Athenaeus states[5] that the Egyptians sometimes built walls of alabaster. The uses of alabaster for purposes other than for building will be dealt with separately.[6]

Basalt[7]

Basalt is a black,[8] heavy, compact rock, often showing tiny glittering particles: it consists of an aggregate of various minerals, which in true basalt are too fine-grained to be distinguished separately, except by means of a microscope, the coarser varieties of rock where the separate minerals can be recognized with the naked eye being dolerite. There is, however, no hard and fast dividing line between the two, a coarse-grained basalt being a fine-grained dolerite, and the material so largely employed in ancient Egypt, being relatively coarse-grained though generally called basalt, is strictly a fine-grained dolerite. However, as the name basalt for this stone has become established so firmly in the literature of Egyptology and as it is neither misleading nor entirely wrong, it is suggested that it should be retained and it will be used in the present book.

Basalt was employed largely in the Old Kingdom as a material for pavements, thus in the Third Dynasty step pyramid at Saqqara and in

[1] *History of Stones*, XV. [2] XXXVI: 12.
[3] XXXVII: 54. [4] V: 11. [5] *The Deipnosophists*, V, 26.
[6] See pp. 463, 481. [7] See pp. 463–4.
[8] The colour is brown when the stone is weathered and partly decomposed.

the large tomb adjoining a few basalt paving blocks were found[1]; the pavement in the Fourth Dynasty pyramid temple of Cheops at Giza (all that now remains of the temple) is of basalt; also pavements of a court, a causeway, two small chambers and a small offering place in a Fifth Dynasty mortuary temple at Saqqara[2] and pavements, and possibly other parts of the buildings, in the mortuary temples of two Fifth Dynasty temple-pyramids at Abusir[3] (between Giza and Saqqara).

Basalt is distributed widely in Egypt and occurs at Abu Za'bal,[4] which is situated about midway between Cairo and Bilbeis; to the north-west of the Giza pyramids[4] (beyond Kirdasa in the Abu Roash area); in the Cairo-Suez desert[5]; in the Fayum[6]; a short distance to the south-east of Samalut in Upper Egypt[7]; at Aswan[8]; in the Baharia Oasis[4]; in the eastern desert and in Sinai.[4]

The basalt employed in such large quantity during the Old Kingdom in the necropolis stretching from Giza to Saqqara was probably local and all the available evidence points to the Fayum as the source. Thus, in the Fayum, within easy reach of this necropolis, there is a basalt quarry[6, 9] approached by a made road, and, therefore, manifestly worked on a large scale and, near the quarry, is a small temple probably of Old Kingdom date and there is no evidence of the ancient quarrying of basalt near Cairo, except in the Fayum, the present quarry at Abu Za'bal being entirely modern. Moreover, the basalt employed in the Old Kingdom is found to be more nearly like that from the Fayum than that from Abu Za'bal.

On this point Miss Caton-Thompson writes[10] 'Microscopical examination of the Fayûm basalt and a specimen from the Fifth Dynasty pavement at Saqqara shows them to be indistinguishable; and although

[1] C. M. Firth and J. E. Quibell, *The Step Pyramid*, pp. 62 (*n.* 1), 93.

[2] C. M. Firth, *Annales du Service*, XXIX (1929), pp. 65, 68.

[3] L. Borchardt, (*a*) *Das Grabdenkmal des Königs Ne-User-Re*, pp. 7, 8, 56, 57, 142, 151; (*b*) *Das Grabdenkmal des Königs S'ahu-Re*, pp. 7, 15, 24, 32, 34, 37, 64, 93, 96.

[4] W. F. Hume, *Explan. Notes to the Geol. Map of Egypt*, pp. 32, 33.

[5] T. Barron, *The Topog. and Geol. of the District between Cairo and Suez*, pp. 103–7.

[6] H. J. L. Beadnell, *The Topog. and Geol. of the Fayum Province in Egypt*, pp. 15, 28, 34, 53, 56, 62.

[7] The information about the Samalut basalt was kindly given by Mr. O. H. Little, Director, Geological Survey, Cairo.

[8] J. Ball, *The First or Aswan Cataract of the Nile*, p. 88.

[9] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 5, 136.

[10] Private communication. See A. Lucas, Egyptian Predynastic Stone Vessels, *Journal of Egyptian Archaeology*, XVI (1930), pp. 204–205.

the rock type is a common one, the presence of similar inclusions in both supports their community of origin.'

Dr. John Ball[1] writes 'I return the specimens and slides of basalt. After examining them myself and finding there was nothing apparently distinctive about the rocks from the different localities[2] I passed them to Andrew.'[3] Mr. Andrew reported as follows: 'The rock coming from the temple of the 1st Pyramid could certainly have come from the same locality as that labelled "Shed[4] el Faras." Whether it did so is not so easy to say,' and again, '1st Pyramid rock resembles Shed[4] el Faras. But this character is quite easily met in greater degree by collecting several specimens from one locality in the basalt.'

Also during the Old Kingdom, another material, gypsum, employed for mortar and plaster in the Giza necropolis, was almost certainly procured, in part at least, from the Fayum[5] and probably certain gypsum vases found at Giza were obtained also from the Fayum.[6]

The former Controller, Department of Mines and Quarries (Sir H. Sadek Pasha), informed me that there was no evidence of any working of the Abu Roash basalt, which would have been the nearest source of supply, and that 'the quality is poor and decomposed.'[7]

Quartzite[8]

Quartzite is a hard, compact variety of sandstone that has been formed from ordinary sandstone by the deposition of crystalline quartz between the sand-grains; that is to say, it is silicified sandstone; it varies considerably both in colour and in texture and may be white, yellowish or various shades of red and either fine-grained or coarse-grained.

Quartzite occurs in various localities in Egypt, notably at Gebel Ahmar,[9] which is situated close to Cairo on the north-east; between

[1] Director, Desert Survey of Egypt.

[2] The specimens were hand specimens and microscopic slides of (*a*) the Fayum basalt; (*b*) the Abu Zaabal basalt; (*c*) basalt from the pavement of the temple of the great pyramid at Giza; (*d*) basalt vase of predynastic date from Ma'adi and (*e*) basalt from Fifth Dynasty pavement at Saqqara (hand specimen only).

[3] Mr. Gerald Andrew, Department of Geology, Egyptian University, now Geologist, Sudan Government.

[4] This should be Widan el Faras, i.e. the Fayum basalt.

[5] See p. 470. [6] See p. 471.

[7] Private communication. [8] See p. 477.

[9] T. Barron, *The Topog. and Geol. of the District between Cairo and Suez*, p. 56.

Cairo and Suez[1]; on the Bir Hammam-Moghara road[2] and at Gart Muluk[2] in the Wadi Natrun depression, both in the western desert, capping the Nubian sandstone on the east of the Nile to the north of Aswan and in Sinai.[3]

Only a few examples are known to me of the use of quartzite as a building material, namely, for the thresholds of several doorways in the pyramid temple of Teti at Saqqara (Sixth Dynasty)[4] and for lining the burial chambers in the Hawara pyramid (Twelfth Dynasty)[5] and in both the north and south pyramids at Mazghuna (Twelfth Dynasty).[6]

The Gebel Ahmar quarries are still worked and until recently there were fragmentary ancient inscriptions in them,[7, 8] but these now no longer exist. This quarry and the stone from it are mentioned several times in the ancient records.[9] The quartzite to the north of Aswan has also been quarried extensively and in one place there is a hieroglyphic inscription, as also an ancient ramp leading down from the quarry.[10]

Quarrying

The quarrying of stone could not, and did not, begin until it was rendered possible by the advent of metal (copper) tools, when for the first time the use of stone on a large scale for building purposes became practicable. The stone used earlier for vases and other comparatively small objects had been procured from blocks that, having been detached from the cliffs by natural processes, were easily accessible, or from boulders found in the ancient dry water courses and at the sides of the river in the cataract areas, and, even after the quarrying of soft stone had become common, one at least of the hard stones, namely

[1] T. Barron, *op. cit*, pp. 61, 62, 103, 104.

[2] W. F. Hume, *Explan. Notes to the Geological Map of Egypt*, p. 16.

[3] T. Barron, *The Topog. and Geol. of the Peninsula of Sinai (Western Portion)*, pp. 163, 199.

[4] J. E. Quibell, *Excavations at Saqqara* (1907–1908), p. 19.

[5] W. M. F. Petrie, (*a*) *Kahun, Gurob and Hawara*, p. 16, and (*b*) *A History of Egypt*, I (1923), p. 196.

[6] W. M. F. Petrie, G. A. Wainwright and E. Mackay, *The Labyrinth, Gerzeh and Mazghuneh*, pp. 44–9, 51–4.

[7] L. Borchardt, *Inschriftfragmente vom Gebel Ahmar*, in *Zeitschrift für ägyptische Sprache und Altertumskunde*, 47 (1910), p. 161.

[8] G. Daressy, *Graffiti de la montagne rouge*, in *Annales du Service*, XIII (1914), pp. 43–7.

[9] J. H. Breasted, *op. cit.*, V (Index), pp. 78, 130.

[10] Information kindly supplied by Mr. G. W. Murray, Desert Survey of Egypt.

granite, was almost certainly obtained for a considerable period from boulders. The method of quarrying stone is inferred from the evidence still to be seen in the ancient quarries, more particularly where there are blocks only partly detached.

Quarrying almost certainly started at Saqqara and developed out of the cutting away of soft limestone rock in order to make tombs, the stone taken out at first probably being in pieces that were both too small and too irregular in shape to be of any use, but later the stone would have been cut out in larger pieces that were roughly shaped and used for lining and flooring tombs excavated in the earth or sand. Still later the stone would have been taken out in larger and more regularly shaped blocks suitable for building.

The quarrying of soft stone (alabaster, limestone and sandstone) has been described by Somers Clarke and Engelbach[1]; by Petrie[2, 3, 4] and by Reisner.[5] It was by isolating a block on four sides by means of trenches cut in the rock and then detaching it from below by the action of wooden wedges or wooden beams wetted with water. The tools employed were chisels of stone and metal (the metal being copper until the Middle Kingdom when bronze was introduced and then either copper or bronze until the advent of iron); wooden mallets and stone hammers.[6, 7] The stone was removed in steps from the top downwards.

At Beni Hasan, where the tombs are of Middle Kingdom date, Fraser found 'ancient stone chisels with which the surfaces of the walls had been dressed down. They are chipped out of the boulders which abound here, the material being a hard, fine, crystalline limestone. They appear to have been used with both hands, and not to have had any hafts.'[8]

Petrie, writing of the tombs of the same period at Qau (Antaeopolis), says[9] 'other tombs of the same period were cut into the rock by pick-work, probably by pointed stone mauls, as on all the quarry working

[1] Somers Clarke and R. Engelbach, *Ancient Egyptian Masonry*, pp. 12–22.
[2] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, p. 70.
[3] W. M. F. Petrie, *Qurneh*, pp. 15–6.
[4] W. M. F. Petrie, *Egyptian Architecture*, p. 26.
[5] G. A. Reisner, *Mycerinus*, pp. 69–70.
[6] Somers Clarke and R. Engelbach, *op. cit.*, p. 17.
[7] G. A. Reisner, *op. cit.*, pp. 69, 232, 236.
[8] G. W. Fraser, *Egypt Exploration Fund, Special Extra Report*, The Season's Work at Ahnas and Beni Hasan, 1890–91.
[9] W. M. F. Petrie, *Antaeopolis*, p. 8.

here; this tomb was bruised out by ball hammers like the granite quarrying at Aswan.'

Howard Carter found at Thebes, of Eighteenth Dynasty date, 'numbers of chert hammers and chisels, and also heaps of flakes, showing that they had been made on the spot. . . . They were probably used for the rougher work when hewing out the rock.'[1]

The apparently rapid development of stone working for building purposes between the early part of the First Dynasty, when stone was first employed on a small scale for tombs, and the beginning of the Third Dynasty, when the step pyramid with the adjoining temples and colonnades, which show a complete mastery of the material, were erected, is not so remarkable as might appear at first sight. Thus the period between the two was about 420 years according to Breasted[2] and about 555 years according to Petrie.[3] Also, the stone used was principally, though not entirely, limestone, since a small amount of granite was also used, and limestone is comparatively soft and easily worked. Further, two important fresh factors were present, namely, the development of copper tools at that particular time, and the plentiful occurrence of limestone in the neighbourhood of the capital, Memphis, where the need for something more endurable than mud brick would have been felt first. These factors appear ample to account for the local development of stone working without the necessity of attributing it to foreign influences. Also, it should not be forgotten that stone working on a small scale was no new thing in Egypt, as is shown by the making of stone vessels, not only of soft stones (alabaster, breccia, limestone, marble, serpentine and steatite), but also of hard stones (basalt, diorite, granite, greywacke (schist) and porphyritic rock), which was practised with great success as early as the predynastic period, and that as far back as the neolithic period, basalt vases had been made.

As already mentioned, it seems highly probable that the quarrying of hard stone from the rock mass was not practised until some considerable time after the quarrying of soft stone had become common, but that granite, the most generally used of the hard stones, was still obtained from large boulders (which are plentiful at Aswan at the present day and which have been used in recent times to supply

[1] The Earl of Carnarvon and Howard Carter, *Five Years' Explorations at Thebes*, p. 10.

[2] J. H. Breasted, *Ancient Egyptian Records*, I, 58.

[3] W. M. F. Petrie, *A History of Egypt*, I (1923), pp. 7, 28.

part of the granite required for the dam) and that it was not until the Middle Kingdom and later, when objects such as huge obelisks and colossal statues were required, that the quarrying of this stone from the living rock was resorted to. The two other hard stones employed for building, namely basalt and quartzite, also may have been obtained at first from fallen or easily detached blocks.

The ancient quarrying of granite and quartzite has been studied by Engelbach,[1, 2] who states that the method used for granite consisted essentially of pounding with balls of dolerite and the use of wedges, the slots for which were cut with a metal tool, and that pounding and wedging were also employed for quartzite with the additional use of another tool, possibly some sort of metal pick.

Stone Working

The ancient method of working stone after it had been quarried may be deduced partly from the tool marks left on objects, particularly on statues, of which a number of unfinished examples are known, but partly also from illustrations of some of the processes that are depicted on certain tomb walls. The subject has been studied by Somers Clarke,[3] Edgar,[4] Engelbach,[5] Petrie,[6] Pillet,[7] Platt,[8] Reisner[9] and others.[10]

The ancient Egyptian stone statues, particularly those in such hard materials as diorite, granite, quartzite and 'schist,' have long been a source of admiration on account of their excellent workmanship, and of wonder and speculation as to the nature of the tools used. Various methods by means of which it is thought these hard stones were worked have been, and from time to time still are, described, these

[1] R. Engelbach, *The Problem of the Obelisks*, pp. 23, 26, 34, 36, 42.

[2] Somers Clarke and R. Engelbach, *op. cit.*, pp. 23–33.

[3] Somers Clarke, *Cutting Granite*, in *Ancient Egypt*, 1916, pp. 110–3.

[4] C. C. Edgar, *Sculptors' Studies and Unfinished Works*, pp. I, IV.

[5] Somers Clarke and R. Engelbach, *op. cit.*, pp. 194, 198, 202–4.

[6] W. M. F. Petrie, (*a*) *On the Mechanical Methods of the Ancient Egyptians*, in *Journ. Anthrop. Inst.*, XIII (1883); (*b*) *The Pyramids and Temples of Gizeh*, pp. 173–7; (*c*) *The Arts and Crafts of Ancient Egypt*, pp. 69–82; (*d*) *Egyptian Architecture*, pp. 27–32.

[7] M. Pillet, L'extraction du granit en Égypte à l'époque pharaonique, *Bull. de l'inst. franc. d'arch. orient.*, XXXVI (1936), pp. 71–84.

[8] A. F. R. Platt, *The Ancient Egyptian Methods of Working Hard Stones*, in *Proc. Society Bibl. Arch.*, XXXI (1909), pp. 172–84.

[9] G. A. Reisner, *op. cit.*, pp. 116–8, 232.

[10] E. Bille-de Mot, Comment les Égyptiens faisaient leurs statues, *Chronique d'Égypte*, 26 (1938), pp. 220–33.

including the use of steel (a very frequent explanation) or of copper or bronze tools set with diamonds or other hard precious stones, and it is refreshing to read Reisner's statement that 'the technical processes used in carving hard stone statues were of the simplest sort, as must be the case when steel is not available.'[1] The principal operations were:

1. Pounding with a stone. Possibly represented in a Fifth Dynasty tomb at Saqqara,[2] in a Sixth Dynasty tomb at Deir el Gebrawi,[3] and in an Eighteenth Dynasty tomb at Thebes.[4]

2. Rubbing with stones held in the hand, probably accompanied by the use of an abrasive powder. Represented in a Fifth Dynasty tomb at Saqqara[2] and in an Eighteenth Dynasty tomb at Thebes.[4]

3. Sawing by means of a copper blade, with the use of an abrasive powder. No representations of this are known.

4. Boring by means of a tubular drill and an abrasive powder, the drill being a hollow tube of copper turned either by rolling between the hands or by means of a bow. A tubular drill was used also for boring out stone vessels, particularly cylindrical jars,[5] and Petrie states[6] that a borer of this kind was used for 'beginning the hollowing out of the great diorite bowls' and also for 'more upright vessels,' of which examples in basalt and alabaster are given. No representations of this are known.

In this connexion another form of boring tool employed for hollowing out stone vessels may be mentioned, namely, a kind of centre-bit provided with an eccentric handle and two heavy weights, the handle probably being of wood and the drill being flint, often crescent-shaped, of which numerous specimens have been found at Saqqara and elsewhere, as also a large number of holes bored with such flints, some at Abusir[7] and others in blocks of limestone of Third Dynasty date at Saqqara,[8] these latter being probably trials by apprentices learning the use of the drill. This drill is represented in various tomb scenes.

[1] G. A. Reisner, *op. cit.*, pp. 117–8.
[2] G. Steindorff, *Das Grab des Ti*, Pl. 134.
[3] N. de G. Davies, *The Rock Tombs of Deir el Gebrâwi*, I, Pl. XVII.
[4] P. E. Newberry, *The Life of Rekhmara*, Pl. XX.
[5] G. A. Reisner, *op. cit.*, p. 118.
[6] W. M. F. Petrie, *Journ. Anthrop. Inst.*, XIII (1883), pp. 6–7 (off-print).
[7] L. Borchardt, *Das Grabdenkmal des Königs Ne-User-Re*, pp. 142–3; Figs. 123–4.
[8] C. M. Firth and J. E. Quibell, *The Step Pyramid*, pp. 124, 126; Pl. 93.

5. Drilling with a copper or stone point with an abrasive powder. In a Fifth Dynasty tomb[1] a drill is being used ' in boring a stone seal,' [2] and in a Sixth Dynasty tomb the drilling of carnelian is pictured,[3] and in various other tombs a drill is shown being rotated by means of a bow for drilling beads and in another tomb for drilling some unknown object.[4]

6. Rubbing with a copper (?) point with abrasive powder. The evidence for this is doubtful. The implement is shown in an Eighteenth Dynasty tomb.[5]

In connexion with the working of hard stones, too much stress is usually laid upon the use of chisels, and those who think that steel must have been used point out that copper and bronze chisels, no matter to what extent they have been hardened by hammering, will not cut such hard stones as diorite, granite and schist, and that they cannot be used with an abrasive powder. This is admitted freely, and chisels certainly were not employed, except for soft stones. But for the use of saws and drills, including tubular drills, there is ample evidence in the marks that remain on the stones on which they have been used.[6] Thus saw marks exist on the basalt of the pavement of the pyramid temple of Cheops[7]; on the red granite sarcophagi of Cheops and Chephren respectively[7]; on the red granite sarcophagus of Hordedef (Fourth Dynasty)[8] found by Reisner at Giza; on the lid of the grey granite sarcophagus of Meresankh[9]; on the back of one of the triads of Mycerinus[10] and on two unfinished alabaster statues of this same Pharaoh.[11] The marks of tubular drills are found on an alabaster statue of Mycerinus[12] and also on an unfinished statue of the same monarch[12]; on the well-known diorite statue of Chephren; in four different sizes in the eye sockets of a Twelfth Dynasty statue in dark

[1] G. Steindorff, *Das Grab des Ti*, Pl. 132.

[2] G. A. Reisner, *Mycerinus*, p. 118.

[3] N. de G. Davies, *The Rock Tombs of Deir el Gebrâwi*, I, p. 20; Pl. XIII.

[4] N. and N. de G. Davies, *The Tombs of Menkheperrasonb, Amenmose and Another*, p. 25; Pl. XXX.

[5] P. E. Newberry, *The Life of Rekhmara*, Pl. XX.

[6] The evidence was first recognized and published by Petrie.

[7] W. M. F. Petrie, *The Pyramids and Temples of Gizeh*, pp. 46, 84, 106.

[8] G. A. Reisner, *op. cit.*, p. 241: Cairo Museum, No. J. 54938. Owner called Djedefher.

[9] Cairo Museum, No. J. 54935B.

[10] Cairo Museum, No. J. 46499.

[11] G. A. Reisner, *op. cit.*, pp. 111, 116.

[12] G. A. Reisner, *op. cit.*, pp. 117, 118.

grey granite[1]; in the eye sockets of a dark grey granite head, probably also of Middle Kingdom date,[2] on an obsidian head of Tuthmosis III from Karnak.[3] Tubular drills were also used for making sockets in the granite of the pyramid temple of Mycerinus to take the ends of door-posts and for bolts,[4] and Petrie gives many additional examples of tubular drill holes and cores.[5] I examined in the store room at Saqqara a large drill core about 8 cm. (approx. 3 in.) in diameter of coarse-grained red granite with green patches on the outside from the copper of the drill, and a small drill core about 3.2 cm. (approx. 1.25 in.) in diameter of diorite. Examples of drilling with a copper or stone point, where the drill holes are still clearly visible and unmistakable, exist in the nostrils, ears and corners of the mouth of an alabaster statue of Mycerinus[6]; on two pieces of inscribed stone vases (Third Dynasty) from the step pyramid at Saqqara. The inscriptions have been described and illustrated by Gunn[7] and the objects are in the Cairo Museum, one (Gunn's No. 4, Pl. I; Museum No. J. 55257) being part of a diorite vase and the other (Gunn's No. 1, Pl. III; Museum No. J. 55273) being part of a vase described by Gunn as diorite, which, however, is not diorite, but probably dolomitic limestone.

The saws and drills, except the 'centre-bit' mentioned, must have been of copper[8] until the Middle Kingdom (about 2000 B.C.) when bronze tools were first used[9] and then either of copper or bronze until iron came into general use,[10] and, as neither copper nor bronze is sufficiently hard to cut such stones as basalt, diorite, granite, quartzite and schist, a harder material than the metal was required to do the work, which must have been used either in the form of cutting points (teeth) or as a loose powder.

The principal advocate of fixed cutting points is Petrie, who stated in 1883[11] that 'The material of these cutting points is yet undetermined; but only five substances are possible: beryl, topaz, chrysoberyl,

[1] L. Borchardt, *Statuen und Statuetten*, II, No. 382; R. Engelbach, *Annales du Service*, XXIX (1929), p. 21.

[2] L. Borchardt, *op. cit.*, II, No. 383: R. Englebach, *op. cit.*, p. 21.

[3] Cairo Museum, No. J. 38248.

[4] G. A. Reisner, *op. cit.*, p. 86. [5] See reference No. 6 (*a*) and (*b*), p. 83.

[6] G. A. Reisner, *op cit.*, pp. 117, 118.

[7] Battiscombe Gunn, *Inscriptions from the Step Pyramid*, in *Annales du Service*, XXVIII (1928), pp. 159, 162.

[8] The hardening of copper is discussed on p. 246.

[9] For bronze and the date of its introduction into Egypt, see pp. 249–54.

[10] The use of iron in Egypt is discussed on pp. 269–74.

[11] W. M. F. Petrie, *The Pyramids and Temples of Gizeh*, p. 173.

corundum or sapphire, and diamond. The character of the work would certainly seem to point to diamond as being the cutting jewel; and only the considerations of its rarity in general, and its absence from Egypt, interfere with this conclusion, and render the tough uncrystallized corundum the more likely material.' In 1925, however, Petrie wrote,[1] 'The cutting of granite was done by means of jewelled saws . . . and jewelled tubular drills. What cutting points were used is unknown, but it seems impossible for corundum to do such cutting through quartz.' In 1937 Petrie stated[2] 'that a slicing tool was used, set with fixed emery points . . .'

With respect to the tubular drills, Petrie states[3] that '. . . not only did the Egyptians set cutting jewels round the edge of the drill tube . . . but . . . they also set cutting stones in the sides of the tube, both inside and out. . . .'

The hardest rock that the ancient Egyptians cut was quartz, either as quartzite (which is wholly quartz) or as quartz crystals in granite and other rocks.[4] The hardness of quartz on the Mohs scale is 7. The five stones mentioned by Petrie, as alone being possible to use for cutting the Egyptian rocks, all have a hardness greater than that of quartz, beryl being 7.5 to 8; topaz, 8; chrysoberyl, 8.5; the gem forms of corundum (ruby, sapphire), 9, and diamond, the hardest of all stones, 10.

Although beryl occurs in Egypt, there is no evidence that it was known before the Greek epoch and the strongest improbability that it was ever obtained in the large quantity that would have been required had it been used for cutting hard stones. The other stones enumerated are not found in Egypt and there is neither evidence nor probability that they were used in ancient Egypt for any purpose, or even that they were known, if at all, until a very late period. The topaz (*topazos*) of Strabo[5] and Pliny[6] (which they state was obtained from an Island in the Red Sea) was probably the modern peridot, which has a hardness of

[1] W. M. F. Petrie, *Ancient Egyptians* (*Descriptive Sociology*), p. 58.

[2] W. M. F. Petrie, *Syro-Egypt*, No. 2, 1937. p. 13

[3] W. M. F. Petrie, *Journ. Anthrop, Inst.*, XIII (1883), p. 7 (off-print).

[4] This refers to working on a large scale, but even on a small scale the hardest stone was quartz in the form of amethyst and rock crystal. Such stones as agate, carnelian, chalcedony, flint and jasper, which also were worked, consist of silica (of which quartz is the crystalline form) and have much the same hardness as quartz. The beryl, which is slightly harder than quartz, was not used until very late and at first it was not cut, but left in the natural (hexagonal) crystalline form.

[5] XVI: 4, 6.

[6] VI: 34; XXXVII: 32.

only 6.5 and which, therefore, is much softer than topaz and too soft to cut quartz.

In my opinion, to suppose the knowledge of cutting these gem stones to form teeth and of setting them in the metal in such a manner that they would bear the strain of hard use, and to do this at the early period assigned to them, would present greater difficulties than those explained by the assumption of their employment. But were there indeed teeth such as postulated by Petrie? The evidence advanced to prove their presence is as follows[1]:

(*a*) A cylindrical core of granite grooved round and round by a graving point, the grooves being continuous and forming a spiral, with in one part a single groove that may be traced five rotations round the core.

(*b*) Part of a drill hole in diorite with seventeen equidistant grooves due to the successive rotation of the same cutting point.

(*c*) Another piece of diorite with a series of grooves ploughed out to a depth of over one-hundredth of an inch at a single cut.

(*d*) Other pieces of diorite showing the regular equidistant grooves of a saw.

(*e*) Two pieces of diorite bowls with hieroglyphs incised with a very free-cutting point and neither scraped nor ground out.

But if an abrasive powder had been used with soft copper saws and drills, it is highly probable that pieces of the abrasive would have been forced into the metal, where they might have remained for some time, and any such accidental and temporary teeth would have produced the same effect as intentional and permanent ones. This possibility is not admitted by Petrie, who states[2] that 'it seems physically impossible that any particle of a loose powder could become so imbedded in a soft metal by the mere accidents of rubbing that it could bear the immense strain . . . needed to plough out a groove of any considerable depth in such a hard material as quartz.' Judging, however, from the analogy of modern 'lapping,' in which a fine abrasive powder is employed with a soft metal (copper, lead or soft alloy), and some of which becomes embedded in the metal during use,[3] it is believed that in the ancient method of working some of the abrasive would have been forced into the metal,

[1] W. M. F. Petrie, (*a*) *Journ. Anthrop. Inst.*, XIII (1883), pp. 2, 15–6 (off-print); (*b*) *The Pyramids and Temples of Gizeh*, pp. 173–4; (*c*) *The Arts and Crafts of Ancient Egypt*, p. 73.

[2] W. M. F. Petrie, *Journ. Anthrop. Inst.*, p. 3 (off-print).

[3] In certain cases the abrasive powder is rubbed into the 'lap' (a disk of soft metal) by means of a hard pebble.

which was the softest of the three substances present (the copper, the abrasive and the stone).

In the discussion that followed Petrie's paper, Mr. (afterwards Sir) John Evans stated[1] that in his opinion the grooves were caused by the drilling tool having been a tube of soft material employed with some hard gritty substance, and that 'it was not improbable that the spiral grooves on the cores were made either in introducing the tube charged with fresh grinding material into the recess or in withdrawing it when clogged.'

In Petrie's discussion of the evidences (*c*) and (*e*), the expressions used 'ploughing out one-hundredth inch thick of quartz at a single cut,'[2] and 'As the lines are only one-one-hundred-and-fiftieth inch wide . . . it is evident that the cutting point must have been harder than quartz,'[3] are somewhat misleading since the material referred to by Petrie was not quartz, but diorite, which is not quite so hard; and since diamond dust is used for cutting diamonds, presumably, therefore, quartz powder might be employed for cutting quartz.

Referring to the schist triads of Mycerinus, Reisner states[4] that 'Some of the signs . . . show slips of a sharp point.'

The sculptors' studies and unfinished works described by Edgar are all of such a late date that the use of iron chisels, or other iron tools, is not only possible but practically certain, as it is known that in the third century B.C. iron tools were being supplied to quarrymen.[5] Edgar says 'Almost all the objects catalogued here are of comparatively late date. The unfinished statues range from the Saïtic period to the Roman annexation . . . It is probable . . . that many of the limestone studies belong to Ptolemaic times.'

'When dealing with these harder stones the sculptors worked mainly with a pointed instrument or punch . . . the marks become smaller and finer as the work advances.'

'For the soft limestone, of which almost all the models are made, a different treatment was adopted, most of the work being done with the chisel instead of the punch. The saw seems to have been used sometimes in the earlier stages when large pieces were being removed from the block . . . The general form was usually given by long regular

[1] W. M. F. Petrie, *Journ. Anthrop. Inst.*, pp. 18–9 (off-print).
[2] W. M. F. Petrie, *Journ. Anthrop. Inst.*, p. 2 (off-print).
[3] W. M. F. Petrie, *The Pyramids and Temples of Gizeh*, pp. 173–4.
[4] G. A. Reisner, *op. cit.*, p. 118 (6).
[5] J. P. Mahaffy, *The Flinders Petrie Papyri*, II, p. 7.

strokes of the chisel or gouge . . . The gouge, which leaves a concave mark . . . was used as well as the straight-edged chisel . . . and the claw chisel was probably known also . . . That a pointed instrument was used for soft as well as for hard stones is shown . . . On finished limestone works one often sees marks of a scraper of some sort.'[1]

I have examined seventeen of these objects[2] made from hard stone (dolerite, greywacke [schist] and grey granite). They are in very different stages of work, and in about half of them the tool marks appear to be those of a chisel, while in other instances a pointed tool has been used.

In my opinion the abrasive material was a loose powder used wet, and Petrie states[3] that 'There is no doubt that sawing and grinding with loose powder was the general method.'

That a hard abrasive powder embedded in or used with a soft material will cut hard stones is well known, and it is stated that in South America a certain tribe of Indians at one time were in the habit of drilling rock crystal by means of a shoot of the wild plantain fed with quartz sand and water,[4] and in one of the museums at Kew Gardens there is a cylinder of quartz, about two to three inches long with a hole through, which is stated to have been bored by means of 'slender strips of the skin of the stem of a species of *Alpinia* twisted rapidly between the palms of the hands, with the addition of a little fine sand,'[5] which are only illustrations of the fact that an abrasive powder can cut a substance as hard as itself, as is proved in the case of the diamond which as already mentioned is abraded by its own dust.

Respecting the nature of the abrasive powder there is much difference of opinion, Petrie being sure that it was emery[6] and Reisner supposing it to have been either emery[7] or pumice,[7] while I venture to suggest that it was neither, but was generally finely-ground quartz sand.

The manner of working stone depicted on certain tomb walls has been referred to already, and beyond the scenes mentioned the

[1] C. C. Edgar, *Sculptors' Studies and Unfinished Works*, pp. I, IV, V.

[2] Nos. 33301–33313, 33321, 33388, 33473, 33476.

[3] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, pp. 73–4.

[4] See discussion on Petrie's paper in *Journ. Anthrop. Inst.*, p. 20 (off-print); also J. D. McGuire, *A Study of the Primitive Methods of Drilling*, no date given.

[5] Royal Botanic Gardens, Kew, *Official Guide to the Museums of Economic Botany*, No. 2, 2nd ed., 1928, p. 49, No. 116.

[6] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, pp. 74, 79.

[7] G. A. Reisner, *op. cit.*, pp. 116, 117, 118.

Egyptian records are silent on the matter. The classical writers, however, give some little information on the subject.

Theophrastus,[1] after enumerating the precious and semi-precious stones known in his day, states that ' some of the stones . . . are of so firm a texture, that they . . . are not to be cut by instruments of iron, but only by other stones.' This author makes no mention of emery, but he describes pumice,[2] though he does not refer to any use of it as an abrasive.

Vitruvius[3] mentions the cutting of stone with a toothed saw, but gives no details of the operation.

Pliny devotes two chapters[4] to the cutting and polishing of stone, chiefly ' marble,' and manifestly the use of an abrasive powder was well known in his day, as also the nature of the function it performed, since he says that the cutting of the stone ' though apparently effected by the aid of iron, is in reality effected by sand; the saw acting only by pressing upon the sand . . .' Among the materials he mentions as being employed for cutting stone are emery (sand of Naxos); ' sand ' from India, Egypt and Nubia and certain stones from Cyprus and Armenia and, for putting the final polish on ' marble,' a material from Egypt (Thebaic stone) and pumice are both recommended.

Emery is an impure variety of corundum, its abrasive power depending largely upon the proportion of crystalline aluminium oxide present, but partly also on its physical condition; its hardness is about 8 and the principal constituent, other than aluminium oxide, is iron oxide. It was obtained originally from several of the islands in the Grecian archipelago, notably Naxos, but it is mined at the present day on a very large scale on the mainland of Asia Minor. Beyond a statement, that has not been confirmed, that some of the sand at Aswan contains 15 per cent of emery,[5] there is no evidence of its occurrence in Egypt.

Pumice is a light spongy lava with a cellular structure, composed chiefly of aluminium silicate. It is obtained principally from the Lipari islands in the Mediterranean, but may be picked up in small quantity on the northern shore of Egypt. Its hardness is 5½ and, therefore, it could not be used to cut quartz. No evidence is known to the author of the use of pumice in ancient Egypt, though a piece of Sixteenth Dynasty date was found at Sedment[6]; two lumps of Nineteenth

[1] *History of Stones*, LXXII, LXXV–LXXVII.
[2] *Op. cit.*, XXXIII–XL.
[3] *De Architectura*, II : 7, 1.
[4] XXXVI : 9–10.
[5] G. A. Wainwright, *Balabish*, p. 38.
[6] W. M. F. Petrie and G. Brunton, *Sedment I*, p. 16.

Dynasty date were found at Gurob[1] and some undated pieces at Coptos.[2]

In the absence of any direct positive evidence respecting the nature of the abrasive powder employed anciently in Egypt, the negative evidence may be considered and is as follows:

A few objects[3] (a plummet; a vase; a tool; three small blocks; a piece and several hones), mostly of early date, found in Egypt, have been stated to consist of emery, but that the material is emery in any case is very doubtful, and that in several instances it is not emery has been proved.[4]

It is much more likely that any abrasive used should have been a local product, rather than an imported material, provided that a substance existed in the country capable of doing the work required, and quartz sand, which occurs in great abundance almost everywhere in Egypt, will abrade and cut diorite and quartz,[5] which were the hardest stones the ancient Egyptians worked.

If emery were the abrasive employed, this can only mean that its properties were familiar at the time of the Third and Fourth Dynasties (nearly 3000 B.C.), not only in Egypt, where stone working on a large scale was only just beginning, but also in its country of origin (Greece), where stone working was then unknown, which seems most improbable.

Whatever abrasive was employed, it must have been used on a very large scale and vast quantities of it must have been consumed, and hence it must have been very plentiful and cheap, which could hardly have been the case had it been imported.

The Egyptians had been working hard stones on a small scale for amulets, beads, mace heads, palettes, vases and other purposes for at least several hundred years before stone was employed for building and it seems reasonable to suppose that the use of sand as an abrasive would have been familiar to them[6] and that when an abrasive was required on a large scale the same material would have been employed. That sand was sometimes used as an abrasive is proved by the finding by Quibell and Green in a vase grinder's workshop of Old Kingdom

[1] W. M. F. Petrie, *Illahun, Kahun and Gurob*, p. 23; *Kahun, Gurob and Hawara*, p. 38.

[2] W. M. F. Petrie, *Koptos*, p. 26.

[3] See p. 294. [4] See p. 295. [5] See p. 54.

[6] Possibly in the case of the harder stones, such as opaque quartz, rock crystal and greywacke ('schist'), the chippings from the roughing-out of the vase or other object may have been ground finely and used as the abrasive.

date 'a quantity of sand that had been used as an abrading material.'[1] Also at the bottom of a hole made by a tubular drill in a fragment of alabaster of Third Dynasty date from the step pyramid at Saqqara[2] there was a compact mass of what was almost certainly the abrasive powder of a light green colour. The powder consisted of naturally-rounded, very fine grains of quartz sand and the colour was due to a copper compound, evidently from the drill used. Myers reports[3] the use of crushed chert or flint for boring a steatite bead.

In all discussions respecting the manner of cutting hard stones in ancient Egypt it should be remembered that the large number of workmen, the long hours worked in the day, the time occupied in the work and particularly the skill, practice and infinite patience of the workmen are all important factors that should be taken into account.

The much-debated questions of the hardening of copper[4] and of the possible use of steel at an early date[5] will be discussed in connexion with the metals.

MORTAR

The mortar employed in ancient Egypt before Graeco-Roman times was of two kinds, depending upon the nature of the construction, namely, clay for use with sun-dried bricks and gypsum for use with stone. The former is still used for sun-dried bricks at the present day and is the most suitable material for the purpose, but gypsum is not now employed as a mortar, having given place to the more recent lime-sand mixture or to the still more modern cement.

No instance of the use of lime mortar in Egypt, or of lime in any form, is known to the author as occurring before the time of Ptolemy I (323 to 285 B.C.)[6] from which period and from later periods it has been found and, from the few specimens analysed,[6, 7] it appears to have been, as is only to be expected, of much the same composition as the lime mortar of to-day.

[1] J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 17.
[2] Cairo Museum, No. J. 65402.
[3] Sir R. Mond and O. H. Myers, *Cemeteries of Armant*, I, p. 79.
[4] See p. 246. [5] See p. 274.
[6] Renato Salmoni, *Sulla Composizione di alcune antiche malte egiziane*, in *Atti e Memorie della R^a. Accademia di Scienze Lettere ed Arti in Padova*—a. 1933 (XI), Vol. XLIX. This reference I owe to Mr. Gilbert Bagnani who kindly gave me a reprint of the article.
[7] See p. 533.

The reason for preferring gypsum to lime, although limestone is very plentiful in the country, even more plentiful than gypsum and also more accessible, was doubtless owing to the scarcity of fuel, lime, as will be shown later when dealing with plaster, requiring a very much higher temperature for burning, and hence more fuel than gypsum, and it was not until the advent of the Greeks and Romans, both of whom knew lime in Europe, where gypsum is useless for outdoor work on account of the wet climate, that lime-burning was practised in Egypt.

Clay Mortar

Clay mortar is simply the ordinary Nile alluvium, consisting of clay and sand, which for use is mixed with sufficient water to bring it to the required consistency. Early instances of the use of clay mortar occur at the step pyramid at Saqqara. In seven specimens of this mortar analysed by me the proportion of clay varied from three per cent to fifty-five per cent.[1]

Gypsum Mortar

The mortar employed in ancient Egypt for stone, as already stated, was of gypsum, which necessarily was burnt and slaked before use. In much of the stone work, however, the individual blocks were so large and many, especially the facing stones, were dressed so truly that mortar as a binding or pointing material was not necessary and, although employed, it was largely as a cushion between the stones to prevent the edges from being damaged while they were being placed in position and as a suitable material on which the large unwieldy blocks of stone could slide and by means of which, therefore, in the absence of pulleys and cranes, they could be adjusted and placed accurately in position.

Resin Mortar

Resin apparently was employed occasionally as mortar, and Montet mentions '. . . *murs cimentés avec de la résine* . . .' in a building of late Persian or early Ptolemaic date at Tanis.

[1] J.-P. Lauer, *La pyramide à degrés*, I, pp. 210, 211, 215–7.

PLASTER

The ancient Egyptian wall plaster was similar in composition to the mortar and consisted of the same two materials, namely, clay and gypsum, and, although both kinds doubtless were employed in house decoration, the houses have largely perished; and except fragments of painted plaster found among the ruins of the palace of Amenophis III,[1, 2, 3] situated to the south of the temple of Medinet Habu, and among the ruins of the palaces and houses at El Amarna,[4-8] practically all the plaster that now remains is that to be found in tombs and temples. A third kind of plaster, used, not for walls, but for covering wood before gilding and painting, will be described later.[9]

Clay Plaster

The use of clay plaster dates from predynastic[10] and early dynastic[11] times. The quality of the plaster varies considerably, but in the main two principal kinds may be recognized, one coarse and generally, if not always, mixed with straw and the other, possibly limited to the Theban necropolis, of better quality, employed both with and without straw, often as a finishing coat to the coarser kind. Both qualities were usually covered with gypsum plaster in order to provide a more suitable surface for painting, a notable exception, however, being at El Amarna, where not only in the private houses, but also in the palaces, the painting was done directly on the clay plaster.

The coarse quality consists of ordinary Nile alluvium, which is essentially a mixture of clay and sand in varying proportions, with

[1] A. E. P. Weigall, *A Guide to the Antiquities of Upper Egypt*, 1913, pp. 290–1.
[2] Robb de P. Tytus, *A Preliminary Report on the Re-excavation of the Palace of Amenhotep III.*
[3] G. Daressy, *Le Palais d'Amenophis III*, in *Annales du Service*, IV (1903), pp. 165–70.
[4] T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I.
[5] F. G. Newton, *Excavations at El-Amarnah, 1923–1924*, in *Journal of Egyptian Archaeology*, X (1924), pp. 289–98.
[6] H. Frankfort, *Preliminary Report on the Excavations at Tell El-Amarnah, 1926–1927*, in *Journal of Egyptian Archaeology*, XIII (1927), pp. 209–18.
[7] H. Frankfort, *Preliminary Report on the Excavations at El-Amarnah, 1928–1929*, in *Journal of Egyptian Archaeology*, XV (1929), pp. 143–9.
[8] J. D. S. Pendlebury, *Preliminary Report of Excavations at Tell El-Amarnah, 1930–1931*, in *Journal of Egyptian Archaeology*, XVII (1931), pp. 233–43.
[9] See p. 403.
[10] J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 21.
[11] W. M. F. Petrie, *The Royal Tombs*, I, p. 9.

generally a small natural admixture of calcium carbonate (carbonate of lime) and occasionally a small proportion of gypsum, which latter, however, is purely accidental and has no binding property, as it has not been burnt.

The better quality is a natural mixture of clay and limestone, both in a very fine state of division, found in hollows and pockets at the foot of the hills and plateaux, from which it has been washed out by the occasional rain storms that occur. This is still employed locally at the present day, under the name of *hîb*, as a finishing coat to sun-dried brick and to coarse clay plaster.

Gypsum Plaster.

This is the characteristic wall plaster of ancient Egypt and is known from early dynastic times and no evidence whatever can be found of the use of lime before the Ptolemaic period,[1] the plaster frequently termed ' lime plaster ' being always gypsum until a late date.

The great use of gypsum plaster was to provide for the walls and ceilings of houses, palaces, tombs and temples a suitable surface for painting upon. Where the wall was plastered with clay, this generally was coated with gypsum plaster, and where clay plaster was not used gypsum plaster was employed for the purpose of covering up faults and irregularities in the stone and of smoothing the surface before painting.

Gypsum, being a natural material, varies considerably both in colour and in composition. The colour may be white, different shades of grey, light brown, or even occasionally pink, examples of pink plaster being in the Twelfth Dynasty tomb of Imhotep at Lisht[2] and in the Eighteenth Dynasty tomb of Tut-ankhamun at Thebes.[3] This latter, however, is merely a surface coloration and is adventitious, being due to chemical changes that have taken place in the iron compounds of the plaster in the course of thousands of years. When the colour is grey, this generally is owing to the presence of small particles of unburnt fuel.

Occasionally the plaster used as a finishing coat, which is white or practically white, contains a very large proportion of calcium carbonate

[1] See p. 93.

[2] A. M. Lythgoe, *Bull. Met. Mus. of Art, New York, Egyptian Exped., 1914* (1915), p. 16.

[3] A. Lucas, *The Tomb of Tut-ankh-Amen*, II, Howard Carter, Appendix II, p. 164.

and very little gypsum and, although this may be a poor quality gypsum containing the calcium carbonate naturally, it may be an artificial mixture, additional calcium carbonate possibly having been added in order to produce a lighter colour in plaster that was not white enough for the purpose required. Sometimes the surface coating is so thin as to be merely a distemper or whitewash and consists essentially of calcium carbonate, which may or may not contain a trace of gypsum, which, however, is probably simply an impurity and not the binding material, since whitewash adheres fairly well to limestone and very well to clay without a binder.

Gypsum occurs plentifully in Egypt in two conditions, one a rock-like formation, which is found to the west of Alexandria; in the district between Ismailia and Suez; in the Fayum and near the Red Sea coast; and the other in scattered masses of loosely-aggregated crystals, which merely have to be dug up from just below the surface of the limestone desert; and it is this latter that was, and still is, used so largely for making plaster. At the present time it is worked in the vicinities of both Cairo and Alexandria and in the district stretching south from Cairo to Beni Suef, but there are small local deposits in other places. As thus found, gypsum is never pure, but contains varying proportions of calcium carbonate and quartz sand, together with small amounts of other ingredients. The presence of the calcium carbonate, which is disclosed readily by chemical analysis, has led those who are not familiar with Egyptian gypsum and who only know the purer European article, to imagine that it is due to an intentional admixture with lime, which in course of time has become converted into carbonate by natural processes, as happens in the case of lime mortar. In the same manner the presence of quartz sand to those who only know of sand in this connexion as a deliberate addition to mortar and plaster is equally confusing and conveys a wrong impression. Ancient Egyptian plaster of the kind under consideration is crude gypsum that has been burnt, powdered and slaked, and any calcium carbonate and sand it contains are not artificial additions, but impurities derived from the raw material in which they occur naturally.

At what date gypsum was first used in Egypt is not known, but a white plaster employed to mend a large red pottery vessel found by Professors O. Menghin and M. Amer in the predynastic site at Ma'adi near Cairo, which was analysed by me, was gypsum.

Some little of the gypsum mortar and much of the plaster used in the Giza pyramids and adjacent tombs and in the tombs at Saqqara

are of particularly good quality, one specimen analysed by me being 99.5 per cent pure and another 97.3 per cent pure, and in view of Miss Caton-Thompson's recent discovery in the Fayum of an outcrop of pure gypsum that had been worked in early dynastic times,[1] it is almost certain that the better quality gypsum employed at Giza and Saqqara was from this source.

Chemically, gypsum is calcium sulphate (sulphate of lime) containing water in intimate combination. On being heated to a temperature of about 100° C. (212° F.) gypsum loses about three-fourths of its water and forms a substance which has the property of recombining with water to produce a material that sets and finally becomes very hard. The temperature usually employed for burning gypsum varies from about 100° C. (212° F.) to about 200° C. (392° F.), but is generally kept about 130° C. (268° F.), which is a heat readily obtained. This temperature is not sufficiently high to convert any calcium carbonate present into quicklime. The calcined material in the pure form as made in Europe is known as 'plaster of Paris.'

In order that the difference of temperature required to produce lime by burning limestone as compared with that needed to calcine gypsum may be appreciated, it may be mentioned that to convert calcium carbonate into quicklime a temperature of about 900° C. (1,652° F.) is required.

Wood

The principal use of wood in building in ancient Egypt was for the doors, sometimes for the roofs[2] and occasionally for the columns[2] of temples; for the doors and roofs of houses and in certain predynastic and early dynastic burials for roofing, flooring and lining graves. Its employment as a building material, however, was not its only, nor its greatest use, and its consideration, therefore, will be deferred to a special chapter.

[1] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 103–23.
[2] G. A. Reisner, *Mycerinus*, pp. 40, 47, 67, 92.

CHAPTER VI

COSMETICS, PERFUMES AND INCENSE

Cosmetics

Cosmetics are as old as vanity. In Egypt their use can be traced back almost to the earliest period of which burials have been found, and continues to the present day.

The ancient Egyptian cosmetics included eye-paints, face-paints and oils and solid fats (ointments), all of which are here considered.

Eye-paints

The two commonest eye-paints were malachite (a green ore of copper) and galena (a dark grey ore of lead), the former being the earlier of the two, but being ultimately largely replaced by the latter, which became the principal eye-paint of the country. Both malachite and galena are found in the graves in several conditions, namely, as fragments of the raw material, as stains on palettes and stones on which this was ground when required for use and in the prepared state (*ḳohl*), either as a compact mass of the finely ground material made into a paste (now dry) or more frequently as a powder. Malachite is known from the Tasian, Badarian and predynastic periods[1, 2, 3, 4] until at least the Nineteenth Dynasty,[5] while galena, although it has once been found from the Badarian period,[6] does not appear generally until a little later[4, 7, 8] but it continues until the Coptic period.[5]

The crude form of both malachite and galena was often placed in the graves in small linen or leather bags. The prepared form has been

[1] G. Brunton, *Mostagedda*, p. 30.
[2] G. Brunton, *Qau and Badari*, I, p. 63.
[3] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 31, 41, 85–7, 99, 102, 103, 109.
[4] W. M. F. Petrie, *Prehistoric Egypt*, p. 43.
[5] A. Wiedemann, *Varieties of Ancient Kohl*, in *Medum*, W. M. F. Petrie, pp. 42, 43.
[6] G. Brunton, *Mostagedda*, pp. 54, 57.
[7] G. Brunton, *Qau and Badari*, I, pp. 13, 31, 63, 70.
[8] Sir R. Mond and O. H. Myers, *Cemeteries of Armant*, I, p. 12.

found contained in shells,[1] in segments of hollow reeds, wrapped in the leaves of plants and in small vases, sometimes reed-shaped.

When *ḳohl* is found as a mass, as distinct from a powder, this has often manifestly shrunk[2, 3] and has also sometimes acquired markings from the interior of the receptacle,[3] from which it is evident that such preparations were originally in the condition of a paste, which has dried. With what the fine powder was mixed to form the paste has not been determined, though, since fatty matter is absent[2] the use either of water or gum and water seems probable. Fatty matter, however, may have been used in applying the *ḳohl* to the face.

The composition of the ancient Egyptian *ḳohl* has been described by various writers, including Wiedemann[4] (from analyses by Fischer); Florence and Loret[5] (who quote Fischer's analyses and in addition give particulars of a few earlier ones and of two of their own); Barthoux[6] (who examined various specimens thought to be *ḳohl*) and myself, who have analysed a large number of specimens, the results of a few of which have been published.[7, 8]

The results of the analyses referred to, omitting those of Barthoux, which will be dealt with separately, show that the material was galena in 40 cases out of 61[9] (approximately 65.5 per cent), while the rest consisted of respectively carbonate of lead[10] (2); black oxide of copper (1); brown ochre[11] (5); magnetic oxide of iron[12] (1); oxide of manganese[13] (6); sulphide of antimony[14] (1);

[1] Shells were also employed as receptacles for pigment other than eye-paint.

[2] A. Wiedemann, *op. cit.*, p. 42.

[3] Particularly noticeable in the case of dry pastes in shells.

[4] A. Wiedemann, *op. cit.*, pp. 41–4.

[5] A. Florence and V. Loret, *Le collyre noir et le collyre vert*, in *Fouilles à Dahchour*, J. de Morgan, 1895, pp. 153–64.

[6] J. Barthoux, *Les fards, pommades et couleurs dans l'antiquité, Congrès Int. de Géog., Le Caire, Avril* 1925, IV (1926), pp. 251–6.

[7] G. Brunton, *Qau and Badari*, I, p. 70.

[8] J. E. Quibell, *Annales du Service*, II (1901), p. 143.

[9] Two with trace of sulphide of antimony and five with carbon.

[10] One with trace of sulphide of antimony.

[11] O. H. Myers (*Cemeteries of Armant*, I, pp. 12, 141) reports the finding of limonite used as a cosmetic from a predynastic tomb. Brown and yellow ochres are merely earthy forms of limonite.

[12] H. E. Winlock (*The Treasure of El-Lahun*, p. 67) publishes an analysis by Kopp of a specimen of *ḳohl* that consisted of black oxide of iron and earthy matter.

[13] Both oxide of manganese and galena were found by the Department of Antiquities of Eleventh Dynasty date at Kom el Hisn (Delta), and these I have examined.

[14] Nineteenth Dynasty date.

malachite[1] (4), and chrysocolla, a greenish-blue ore of copper (1).

It will be seen that only one of the specimens consisted of an antimony compound and only three others contained any antimony compound and those only a trace, manifestly present as an accidental impurity. The general idea, therefore, that ancient Egyptian *ḳohl*, except when it was the green malachite or chrysocolla, always either consisted of or contained antimony or an antimony compound is wrong, and hence it is most misleading to term it *stibium* (an early Latin name for sulphide of antimony, transferred later to the metal), as is sometimes done. The mistake possibly arose from the fact that among the Romans an antimony compound, called by Pliny[2] *stimmi* and *stibi*, was employed in eye-cosmetics and eye-medicines.

Lane states[3] that the ordinary Egyptian *ḳohl* of his day consisted of smoke-black (soot) made by burning either a cheap kind of frankincense or the shells of almonds and that the special quality used on account of its supposed medicinal properties contained, besides carbon, a variety of other ingredients, which he enumerates, and which include lead ore, but among which there is no mention of any antimony compound. The present-day Egyptian *ḳohl* also consists of soot, made, according to Brunton,[4] by burning the safflower plant (*Carthamus tinctorius*), and is applied by means of a small wooden, bone, ivory or metal rod, the tip of which is moistened with water and dipped into the powder. These rods only began to appear in the Eleventh Dynasty, before which time the *ḳohl* was probably put on with the finger. Budge found[5] that certain specimens of modern *ḳohl* from the Sudan consisted of black oxide of manganese. Sonnini in 1780 said that in Egypt a mixture of blacklead (galena) and lamp black was used.[6]

Barthoux's account of the composition of ancient Egyptian *ḳohl*[7] is disappointing, as the dates and particulars of origin of the specimens, as well as the number of each kind examined, are omitted. Although the correctness of the analytical results is not questioned, it is probable

[1] One specimen was mixed with resin, but Florence and Loret (*op. cit.*, p. 161) contend that this was a medicinal preparation and not *ḳohl*.

[2] XXXIII, 33, 34.

[3] E. W. Lane, *The Manners and Customs of the Modern Egyptians* (Everyman's Library), p. 37.

[4] G. Brunton, *Qau and Badari*, I, p. 63.

[5] E. A. Wallis Budge, *The Mummy*, 2nd ed. (1925), p. 259.

[6] C. S. Sonnini, *Travels in Upper and Lower Egypt*, trans. H. Hunter, I, p. 263.

[7] The word employed is '*fards*,' which is used apparently to mean eye-paints and not cosmetics generally.

that several of the specimens were not eye-paints and that others were not even cosmetics of any sort. The greater proportion consisted wholly or partly of galena; the rest included carbonate of lead; a compound of antimony and lead (the only one in which any antimony compound occurred); vegetable black (i.e. soot obtained by burning vegetable matter); compounds of arsenic (both with and without admixed iron pyrites, some being orange-coloured and probably none of them cosmetics) and chrysocolla. Another of the specimens Barthoux suggests may have been composed of bitumen impregnated with aromatic essences. This is described as being chestnut-brown, which is not the colour of bitumen, and apart from the improbability of bitumen having been employed for such a purpose, for which it would be most unsuitable, aromatic essences as separate entities, that could be employed for impregnating other substances, were unknown to the ancient Egyptians, since to obtain them a knowledge of distillation would have been necessary, and this process was not discovered until a very late date.[1] A further specimen was rose-coloured and consisted of a mixture of common salt, sodium sulphate, haematite and organic matter, but the composition makes it doubtful whether it was a cosmetic of any sort, and it was almost certainly not an eye-paint. Wax and fatty matter occurred in several instances, but these specimens, although they may have been cosmetics, were probably not eye-paints, since all the specimens of *ḳohl* analysed by Fischer,[2] Florence and Loret,[3] and myself have been free from these substances. In a few cases, too, resin (sometimes aromatic) was present, but these also are unlikely to have been eye-paints, since all the specimens of *ḳohl* analysed by others have been free from resin. In one case it is true that a powder examined by von Baeyer consisted of malachite and resin, but Florence and Loret consider this to have been a medicament and not an eye-paint on account of the inscription on the receptacle.[4] Although resin is frequently found in graves, particularly in those of early date, close to or associated with the eye-paint materials malachite and galena, there is no evidence to show that it was used with them, and, as already mentioned, all the prepared eye-paints analysed have been free from resin, except the few specimens reported by Barthoux, and that these were indeed eye-paint needs confirmation. In view of Elliot Smith's

[1] See p. 33.
[2] A. Wiedemann, *op. cit.*, pp. 41–4.
[3] A. Florence and V. Loret, *op. cit.*, pp. 153–64.
[4] A. Florence and V. Loret, *op. cit.*, p. 161.

statement[1] that the malachite and resin were ground together on the slate palettes (also frequently found in the graves), a number of experiments were made by me with specimens of ancient malachite and ancient resin and also with ancient malachite and modern resin (colophony) which were ground together to a very fine powder and applied to the face and in no instance was there any satisfactory adhesion to the skin.

The contents of a small greenish-blue glass bottle, one of about a dozen in the possession of an antiquity dealer in Cairo and probably of Roman date, analysed by me proved to be haematite (oxide of iron) in fine powder.

The materials of the early eye-paints, malachite and galena, are both products of Egypt, malachite being found in Sinai and in the eastern desert and galena near Aswan and on the Red Sea Coast. The additional materials occasionally employed later, namely carbonate of lead, oxide of copper, ochre, magnetic oxide of iron, oxide of manganese and chrysocolla are also all local products, the only exceptions being compounds of antimony, which, so far as is known, do not occur in Egypt, but which are found in Asia Minor, Persia and possibly also in Arabia.[2]

According to the ancient records eye-paint was obtained in the Twelfth Dynasty from the Asiatics,[3] in the Eighteenth Dynasty from Naharin in western Asia[4] and from Punt,[5] and in the Nineteenth Dynasty from Coptos.[6] Although there was no necessity for the Egyptians to import eye-paint from abroad, since all the materials employed, except the very rarely used antimony compounds, occur naturally in the country, there would not have been any difficulty in obtaining it from Asia, where the various materials also occur. The eye-paint from Coptos that so puzzled Max Müller[7] may well have been galena from the Red Sea coast, but what eye-paint could have been brought from Punt is a question not easily answered. Punt is chiefly associated with odoriferous gum-resins used as incense (which in the list of articles obtained are enumerated separately), but these

[1] G. Elliott Smith, *In the Beginning*, p. 57.

[2] R. F. Burton, (*a*) *The Gold Mines of Midian*, pp. 168, 375, 390; (*b*) *The Land of Midian*, I, pp. xxii, 194.

[3] J. H. Breasted, *Ancient Records of Egypt*, I, p. 281, n.d.

[4] II, 501. [5] II, 265, 272.

[6] A. Erman, *The Literature of the Ancient Egyptians*, trans. A. M. Blackman, p. 34.

[7] W. Max Müller, *Egyptological Researches*, II, pp. 88–9.

are not eye-paints, though they were sometimes employed to impart a fragrance to ointments used as cosmetics. It is certainly possible, however, although it seems unlikely, that some mineral substance, not native to Punt (since none likely to have been sent to Egypt is known to occur there) may have reached Egypt by way of Punt, in the same manner as in Roman times produce from India was carried to ports on the African coast and thence trans-shipped to Italy. If this were so, the material referred to may have been malachite or galena, which were the principal eye-paints of ancient Egypt and both of which occur in Arabia.[1, 2]

Face-paints

In addition to painting round the eyes, the ancient Egyptian women probably sometimes also coloured their cheeks, since this is the most reasonable explanation of certain red pigment found in the graves associated with palettes[3, 4] and as stains on palettes[4, 5, 6, 7, 8, 9] and stones[10] on which it was ground for use. This pigment is a naturally occurring red oxide of iron, generally termed haematite, but which would be more correctly described as red ochre.[11]

Oils and Fats

As oils and fats used as cosmetics were frequently scented, except when employed by the poorer classes, they will be dealt with as perfumes.

[1] R. F. Burton, *op. cit.*, (*a*) pp. 141, 204, 219, 228, 390; (*b*) I, pp. xi, xxi, xxiii, 55, 66, 75, 76, 267, 269; II, p. 53.

[2] R. F. Burton, *op. cit.*, (*a*) pp. 11, 204, 390; (*b*) I, pp. xxii, 266, 269; II, pp. 191, 242.

[3] C. M. Firth, *Arch. Survey of Nubia, Report for 1910–1911*, p. 157.

[4] G. Brunton, *Mostagedda*, pp. 30, 57, 109.

[5] W. M. F. Petrie, *Prehistoric Egypt*, p. 37.

[6] W. M. F. Petrie and J. E. Quibell, *Nagada and Ballas*, p. 43.

[7] W. M. F. Petrie and E. Mackay, *Heliopolis, Kafr Ammar and Shurafa*, p. 18.

[8] G. Brunton and G. Caton-Thompson, *op. cit.*, p. 31.

[9] J. E. Quibell, *Archaic Objects*, I, pp. 226, 227.

[10] G. Brunton, *Qau and Badari*, I, p. 62.

[11] Red ochre, which was the only red pigment known in ancient Egypt until very late, was also much employed for painting tombs and other objects, as also by the scribes in writing, and it is found in graves, apart altogether from palettes and from any suggestion of its use in personal adornment.

PERFUMES

The perfumes of ancient Egypt consisted chiefly of fragrant oils and fats (ointments), the use of which is mentioned frequently in the ancient records[1, 2] and by several of the Greek and Roman writers. That in a hot, dry climate, such as that of Egypt, oils and fats should have been applied to the skin and hair was only natural, and the practice is common in Nubia, the Sudan and other parts of Africa at the present day. The oil was of more than one kind, that used by the poorer classes, according to Strabo,[3] being castor oil, which is still used for this purpose in Nubia. Of solid fats the choice was small, being limited to animal fats.

From purely theoretical considerations alone it is exceedingly probable that fragrant substances were sometimes added to these oils and fats, not only to render them more pleasing, but also to mask the tendency of such materials to become rancid and disagreeable. Fortunately, however, it is not necessary to rely on conjecture as there is definite evidence that such indeed was the case, as will now be shown.

The modern liquid scents and perfumes are solutions in alcohol of various odoriferous principles derived from the flowers, fruits, wood, bark, leaves or seeds of plants, but more generally from flowers. Such perfumes cannot have been known in ancient Egypt, since to produce many of them, as well as to produce the alcohol to dissolve them, a knowledge of the process of distillation is essential, and this was almost certainly not discovered until a late period, the earliest reference to it that can be traced being one by Aristotle[4] in the fourth century B.C. Both Theophrastus[5] (fourth to third century B.C.) and Pliny (first century A.D.)[6] also mention distillation, and from the methods described it seems clear that the process was then in a primitive and, therefore, presumably early stage.[7]

After alcohol, the next best medium for absorbing and retaining odours is fat or oil, a fact that is largely made use of at the present day to abstract the scent from flowers, the petals of which are placed in layers of solid fat or soaked in oil, the perfume being afterwards removed by means of alcohol, in which condition it is used. This method, at least in its entirety, must have been unknown until the

[1] J. H. Breasted, *op. cit.*, v (Index), pp. 123, 149.
[2] A. Erman, *op. cit.*, pp. 8, 61, 99, 102, 156, 202, 207, 209, 244, 246, 249.
[3] XVII: 2, 5. [4] *Meteorologica*, I: 9, 11; II: 3.
[5] *Enquiry into Plants*, IX: 3, 1–3.
[6] XV: 7; XVI: 21–2. [7] See p. 377.

process of separating alcohol by distillation from fluids containing it was discovered, though a partial application of it would have been possible without alcohol, since after the fat or oil had become thoroughly impregnated with the perfume, if the exhausted petals had been picked out, strained out or otherwise removed, a scented fat or oil would have remained. A method of this kind was practised by the Greeks in the time of Theophrastus,[1] the oil most used being that from the Egyptian or Syrian *balanos*[2] (*Balanites aegyptiaca*), though olive oil and almond oil were also employed; it is described by Dioscorides[3] in connexion with oil of lilies, the Egyptian make of which he says was one of the best. A similar method was also in use by the Romans of Pliny's day,[4] various plants and plant products being left to steep in oil and then pressed, or sometimes boiled in oil. That a corresponding process was also employed in Egypt seems indicated by Pliny's enumeration of various oils among the constituents of Egyptian unguents.[5]

The process of pressing flowers, gum-resins and other fragrant materials with oil, and the removal of the perfumed oil from the exhausted material was by wringing or squeezing in a cloth or sack, exactly in the same manner as the skins and stalks of grapes were pressed. This is proved by several representations from tomb walls, for example, one in a Middle Kingdom tomb at Beni Hasan, now destroyed, but copied by Cailliaud in 1831,[6] another on a bas-relief of 'neo-memphite' date in the Louvre Museum,[7] and a third on a bas-relief of Ptolemaic date in the Museum Scheurleer, Holland.[8] The perfume in each case is that from lilies.

Egyptian perfumes are described by both Theophrastus and Pliny[9] and are mentioned by Athenaeus,[10] who calls them the best, and expensive. Theophrastus states that one was made from several ingredients, including cinnamon and myrrh[11] (the other ingredients not being named) and that a certain perfumer 'had had Egyptian perfume in his shop for eight years . . . and that it was still in good case, in fact better than fresh perfume.' Pliny says that Egypt was the country best suited of all for the production of unguents, and that at

[1] *Concerning Odours*, IV: 14. [2] *Op. cit.*, IV: 15, 16, 19. [3] I: 62.
[4] XIII: 2; XV: 7. [5] XIII: 2.
[6] F. Cailliaud, *Recherches sur les arts et métiers*, 1831, Pl. 15A.
[7] *Monuments et mémoires Piot*, XXV, Pls. IV, V. VI.
[8] Von Bissing, *Bull. van de Vereeniging tot Bevordering der Kennis van de antieke Beschaving*, IV (1939), 9–14.
[9] XIII: 2, 6. [10] *The Deipnosophists*, I: 66; III: 124; XII: 553.
[11] *Concerning Odours*, VI: 28, 30, 31; IX: 38; X: 42, 44; XI: 55.

one time those most esteemed in the Roman world were from Mendes, and he describes the Mendesian unguent as being of a very complex composition, consisting originally of oil of *balanus*,[1] resin and myrrh, but at a later period containing an Egyptian oil extracted from bitter almonds (*metopium*), oil of unripe olives (*omphacium*),[2, 3] cardamoms, sweet rush, honey, wine, myrrh, seed of *balsamum*, galbanum and turpentine resin. A Mendesian unguent made from balanos oil, myrrh, cassia and resin is also mentioned by Dioscorides.[4] Pliny also states that the *myrobalanum*, which grew in the country of the Troglodytae, in the Thebaid and in the parts of Arabia that separate Judea from Egypt, yielded an oil particularly suitable for unguents[5]; also that Egyptian *elate*[6] or *spathe*[6] and the fruit of a palm called *adipsos*[7] were all used in making unguents; he also mentions another Egyptian unguent made from *cyprinum* which he states was an Egyptian tree[8] and which was probably henna, the flowers of which are odoriferous.

Bitter almond oil (*metopium*) is mentioned by Dioscorides,[9] but this writer also describes[10] an Egyptian ointment called *metopion*, which was made from bitter almonds, *omphacine* oil, cardamoms, *schoenus*, *calamus*, honey, wine, myrrh, *balsamum* seed, galbanum and resin.

In connexion with henna it may be mentioned that the leaves were possibly used in ancient Egypt, much as they are to-day, in the form of a paste to colour the palms of the hands, the soles of the feet, the nails and the hair. Thus, the Romans certainly employed henna, an Egyptian shrub, for colouring the hair,[11] and probably therefore also the Egyptians.[12]. Newberry identified twigs of henna from the Ptolemaic cemetery at Hawara.[13]

Besides the perfumes from plants already dealt with and in the absence of animal perfumes (the principal being ambergris, civet and musk), for the use of which in ancient Egypt there is no evidence, the only other likely odoriferous substances that remain for consideration are the plant products, resins and gum-resins, for the use of which to perfume oils and fats there is a certain amount of positive evidence, that may now be considered.

[1] See p. 383.
[2] XII: 60; XXIII: 39. The same name was also given to the juice of unripe grapes.
[3] I: 29. [4] I: 72.
[5] XII: 46. The *myrobalanum* of the ancients was *Moringa aptera* or *M. oleifera*, and the oil was ben oil. See p. 384.
[6] XII: 62. [7] XII: 47. [8] XII: 51. [9] I: 39. [10] I: 71.
[11] XXIII: 46. [12] See p. 356.
[13] P. E. Newberry, in *Hawara, Biahmu and Arsinoe*, W. M. F. Petrie, p. 50.

The statement of Theophrastus that a certain Egyptian unguent contained myrrh has already been quoted, as also that of Dioscorides that one Egyptian unguent contained myrrh, galbanum and resin, and that the Mendesian unguent contained myrrh and resin, and that of Pliny that resin, turpentine resin, myrrh and galbanum entered into the composition of the Mendesian unguent, and to these may be added some slight evidence from the Egyptian records and from the tombs. Although as a rule there is little to suggest that any of the oils, fats and ointments, so frequently mentioned in the records, were scented (there being usually either no description of the material or merely a statement of the purpose for which it was employed), there are several exceptions, namely one instance in which the 'smell of unguents' is referred to,[1] two others in which 'sweet oil of gums'[2] and two in which 'ointment of gums'[3] respectively are named and, since gums are not odoriferous, but since resins and gum-resins are even to-day often wrongly termed gums, the names suggest a possibility that the oil and ointment referred to may have been perfumed by means of fragrant resins or gum-resins.

From the tombs the evidence leaves much to be desired, but definite facts are gradually being accumulated. Fatty matter has often been found in graves, and this frequently possesses a strong smell,[4, 5, 6] but probably in no instance is the smell the original one, nor can it reasonably be called a perfume; in all the cases known to me it has always been a secondary smell due to chemical changes that have taken place in the fat, often being suggestive of rancid coconut oil and occasionally of valeric acid.[7] Very few examples of this fatty matter have been analysed, and there is no definite proof that any of the specimens were cosmetics, though in one instance this is very probable. Sometimes the fatty matter consists largely of mixed palmitic and stearic acids,[8, 9, 10] probably representing an original animal fat. Four specimens examined

[1] A. Erman, *op. cit.*, p. 156.
[2] J. H. Breasted, *op. cit.*, IV, 497, 498.
[3] IV, 476, 477.
[4] W. M. F. Petrie, *The Royal Tombs*, I, p. 14
[5] G. A. Wainwright, *Balabish*, p. 14.
[6] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 27, 39, 40.
[7] See Chapter XIII, Oils, Fats and Waxes.
[8] A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, Appendix II, pp. 176, 177.
[9] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 39.
[10] A. C. Chapman and H. J. Plenderleith, *Examination of an Ancient Egyptian (Tut-ankh-Amen) Cosmetic*, in (*a*) *Journ. Chem. Soc.*, CXXIX (1926), pp. 2614–19; in (*b*) *The Tomb of Tut-ankh-Amen*, Howard Carter, II, Appendix, IV, pp. 206–10.

have been mixed with solid material that has not been identified,[1, 2] but which in one instance was possibly a balsam.[3] According to Pliny,[4] however, the Roman perfumers of his day (and possibly, therefore, the Egyptian perfumers also) thought that gum or resin added to a cosmetic fixed the perfume, and it seems possible that the solid matter referred to may have been, not a fragrant resin or gum-resin added to perfume the fat, but a non-odoriferous gum or resin used to fix a perfume obtained from some other source. Five specimens of material, all very much alike, from different compartments of a toilet box of unknown date examined by Gowland gave results from which he concluded that the material consisted of beeswax mixed with an aromatic resin and a small proportion of vegetable oil.[5]

According to Dioscorides, the Egyptians knew the root of the iris as a perfume[6]; he says, too, that *Balsamon* (*Balsamodendron opobalsamum*) grew in a certain valley in Judea (the Jordan Valley) and in Egypt.[7] This is probably the modern *Mecca Balsam*, but that it ever grew in Egypt is most unlikely. Schweinfurth, however, states that it grew in south Nubia.[8] The incense *Kyphi* used in ancient Egypt, of which so much has been written, was a very composite material. Plutarch says[9] that it consisted of sixteen ingredients; Dioscorides,[10] however, gives only ten. Several of the ingredients have not been identified with certainty.

Eight specimens of materials of unknown date, thought to be perfumes, examined by Reutter, are stated to have consisted generally of a mixture of all or most of the following named substances: storax, incense, myrrh, turpentine resins, bitumen of Judea perfumed with henna, aromatic vegetable material mixed with palm wine or the extract of certain fruits (such as cassia or tamarind) and grape

[1] A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, Appendix II, pp. 176, 177.

[2] These included the specimen examined by Chapman and Plenderleith and previously by me together with three apparently somewhat similar specimens examined by me.

[3] A. C. Chapman and H. J. Plenderleith, *Examination of an Ancient Egyptian (Tut-ankh-Amen) Cosmetic*, in (*a*) *Journ. Chem. Soc.*, CXXIX (1926), pp. 2614–19; in (*b*) *The Tomb of Tut-ankh-Amen*, Howard Carter, II, Appendix, IV, pp. 206–10.

[4] XIII: 2.

[5] W. Gowland, *Proc. Bibl. Arch.*, XX (1898), pp. 268–9.

[6] I: 1. [7] I: 18.

[8] G. A. Wainwright, *Balabish*, p. 14, n.2.

[9] Plutarch, *Isis and Osiris*, French trans. by M. Meunier, pp. 52, 81.

[10] I: 24.

wine.[1] These analyses were made on very small quantities of materials (from 0.498 gram to 2.695 grams), and the conclusions are much too definite for the chemical results obtained. Thus, that a very minute residue of black material, suggestive of bitumen and containing sulphur, was obtained from each specimen is not questioned, but the evidence is not sufficient to prove that this was bitumen of Judea.[2] Such a residue is not infrequent in the case of organic substances of the nature of those examined, especially when they are several thousands of years old. That bitumen was added to perfumes and in such very small proportions as the black residue represented is not only not warranted by the evidence, but is most improbable. The correctness, too, of the identification of so many different substances in the one mixture, particularly when dealing with such small quantities as were examined, needs confirmation.[3]

Incense

Since the word incense (Latin *incendere,* to burn or kindle) has the same literal meaning as the word perfume, which is the aroma given off with the smoke (*per fumum*) of any odoriferous substance when burned, incense, therefore, should be included in any description of ancient Egyptian perfumes.

That incense was employed in ancient Egypt there can be no doubt. Both incense[4, 5] and incense burners (censers)[6] are mentioned in the ancient records, and the offering of incense is shown in the illustrations to the Book of the Dead and is one of the commonest subjects pictured in temples and tombs, and incense[7, 8, 9] and incense burners[10–15] have been found in graves.

[1] L. Reutter, *Analyses des parfums égyptiens,* in *Annales du Service,* XIII (1914), pp. 49–78. [2] See p. 349. [3] See p. 367. [4] J. H. Breasted, *op. cit.,* V (Index), p. 134.
[5] A. Erman, *op. cit.,* pp. 28, 33, 34, 40, 91, 102, 103, 105, 133, 209, 235, 239, 247, 287, 293. [6] J. H. Breasted, *op. cit.,* V (Index), p. 113.
[7] E. R. Ayrton, C. T. Currelly and A. E. P. Weigall, *Abydos,* III, p. 34.
[8] A. Lucas, in *The Tomb of Tut-ankh-Amen,* Howard Carter, II, Appendix II, p. 184; III, Appendix II, p. 181.
[9] G. A. Reisner, *Arch. Survey of Nubia, Report for 1907–1908,* I, p. 85.
[10] G. Brunton, (*a*) *Qau and Badari,* I, p. 35; (*b*) *Qau and Badari,* II, p. 6; Pl. LXXXVIII, 98 d.
[11] G. A. Reisner, *op. cit.,* pp. 78, 82, 83, 85, 86, 87, 89, 90, 91, 92.
[12] C. M. Firth, *Arch. Survey of Nubia, Report for 1909–1910,* p. 112; *Report for 1910–1911,* pp. 52, 53, 57, 59, 60, 61, 65, 66, 73, 78, 199.
[13] W. M. F. Petrie, *Dendereh,* p. 34.
[14] H. Frankfort, *The Cemeteries of Abydos: Work of the Season 1925–1926,* in *Journal of Egyptian Archaeology,* XVI (1930), p. 217.
[15] G. Brunton, *Mostagedda,* p. 124.

At what date incense was first used in Egypt is uncertain, but the earliest references that can be traced are of the Fifth[1] and Sixth[2] Dynasties respectively, and an incense burner of the Fifth Dynasty[3] has recently been discovered. The earliest certain incense of which I have any knowledge is from the end of the Eighteenth Dynasty, which was in the shape of small balls similar to those so frequently depicted on monuments.[4] Incense of the Ptolemaic period from the graves of the priests of Philae found by Reisner was also partly in the form of balls and partly as disks.[5] It is recorded, too, that incense was among the foundation deposits of the tomb of Aahmes I,[6] but that this was prepared incense, such as that just mentioned, needs confirmation. It is described as being in 'pieces' and is much more likely to have been the dark brown resin, lumps of which so frequently occur in graves, particularly, but not exclusively, in those of early date, and although it may have been incense, this is not certain. Two small balls of incense from the Graeco-Roman cemetery at Hawara are in the Kew Museum.[7]

The two best known and most important incense materials are frankincense and myrrh, which may now be described.

Frankincense (Olibanum)

This has been regarded from a very early period, and is still regarded, as true or genuine incense. It is a fragrant gum-resin occurring in the form of large tears, generally of a light yellowish-brown colour, though the purer varieties are almost colourless or of a slight greenish tint.[8] It is translucent when fresh, but after transport (which is necessarily the condition in which it comes into commerce) it becomes covered with its own fine dust, produced by friction between the pieces, and the outside is then semi-opaque. Most other incense materials are more definitely coloured, many of them being dark yellow, dark yellowish-red, yellowish-brown or, in a few cases, grey or black. The

[1] J. H. Breasted, *op. cit.*, I, 161. [2] I, 336, 369.

[3] H. Frankfort, *The Cemeteries of Abydos: Work of the Season 1925–1926*, in *Journal of Egyptian Archaeology*, XVI (1930), p. 217.

[4] A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, Appendix II, p. 184; III, Appendix II, p. 181.

[5] G. A. Reisner, *Arch. Survey of Nubia, Report for 1907–1908*, I, p. 85.

[6] E. R. Ayrton, C. T. Currelly and A. E. P. Weigall, *Abydos*, III, p. 34.

[7] Museum No. I, No. 155/1888.

[8] Bertram Thomas, *Arabia Felix*, p. 122; R. H. Kiernan, *The Unveiling of Arabia*, 1937, p. 213.

white incense, therefore, mentioned in the Papyrus Harris[1] (Twentieth Dynasty) suggests frankincense, since this is more nearly white than any other incense material. Pliny states that whiteness was one of the features whereby a good quality of frankincense (Latin, *Thus*) might be recognized,[2] and its name in Hebrew, Greek and Arabic signifies milk-white.

Frankincense is yielded by certain small trees of the genus *Boswellia*, growing principally in Somaliland and southern Arabia. A variety of frankincense, however, is obtained from *Commiphora pedunculata*, which grows in the eastern Sudan near Gallabat[3] and also in the adjoining parts of Abyssinia. The statements in the ancient records, therefore, that incense reached Egypt from Negro tribes in the Sixth Dynasty[4] and from Punt in the Eighteenth[5] and Twentieth[6] Dynasties in no way conflict with its having been frankincense, since Punt (whether Somaliland or southern Arabia) is the home of frankincense, while the Negro tribes dwelt to the south of Egypt, and a product of Punt or of the eastern Sudan might easily have passed through their country on its way to Egypt. Even the incense obtained from Retenu,[7] Zahi[8] and Naharin[9] in the Eighteenth Dynasty may have been, at least in part, frankincense, since there would not have been any great difficulty in a product of southern Arabia reaching western Asia, though, on the other hand, this source suggests some other kind of incense material.

Pliny quotes King Juba for the statement that the frankincense tree (*Thus*) grew in Carmania and Egypt, 'where' (apparently Egypt is meant) it was introduced by the Ptolemies,[10] but in another place[11] he says that it was ladanum that was found originally in Carmania, and that was planted by order of the Ptolemies 'in the parts beyond Egypt.'

The trees brought by Hatshepsut's expedition from Punt, which are depicted on the walls of the queen's mortuary temple at Deir el Bahari, are termed myrrh by Breasted[12] and frankincense by Naville[13] and

[1] J. H. Breasted, *op. cit.*, IV, 233, 239, 299, 344, 376. [2] XII: 32.

[3] Through the courtesy of the District Commissioner, Gallabat, I have been able to obtain some of this incense for examination. There are specimens of it in the Imperial Institute Museum, London.

[4] J. H. Breasted, *op. cit.*, I, 336, 369. [5] II, 265. [6] IV, 130.

[7] II, 447, 472, 473, 491, 518, 525, 616. [8] II, 462, 509, 510, 519.

[9] II, 482. [10] XII: 31. [11] XII: 37.

[12] J. H. Breasted, *op. cit.*, II, 264, 265, 272, 288.

[13] E. Naville, *The Temple of Deir el-Bahari*, III, p. 12.

are stated by Schoff[1] to be *Boswellia Carteri*, the frankincense tree of Dhofar in southern Arabia. Representations of about 30 trees, or parts of trees, still exist on the walls of the temple, two forms being shown, one having luxuriant foliage and the other being quite bare, but whether they are the same tree depicted differently or at different seasons of the year, or whether they are two entirely different trees there is nothing to indicate. In any case, however, they are drawn in so conventional a manner that there cannot be any certainty about their identity. Schoff takes note only of the trees with foliage (which are those usually copied) ignoring altogether those without foliage, and he says that the rich foliage cannot be meant to represent 'the bare, thorny, trifoliate, but almost leafless myrrh tree, nor the almost equally leafless varieties of Somaliland frankincense.' It is possible, however, that the trees without foliage may be intended for one of these.

Among the imports into Egypt in the Roman period on which duty was levied was frankincense[2] (both African and Arabian), and Pliny states[3] that this material was prepared for sale (presumably by cleaning and sorting) at Alexandria.

Lane says[4] that the Egyptian women of his day chewed frankincense in order to perfume their breath, which is still a custom.

The incense from the tomb of Tut-ankhamun already mentioned, which has been examined by me, is possibly frankincense. It is of a light yellowish-brown colour, brittle, slightly resinous-looking, burns with a smoky flame, giving off a pleasant aromatic odour and has a solubility of approximately 80 per cent in alcohol and 20 per cent in water and is therefore a gum-resin and so cannot be ladanum, Mecca balsam or storax, and the colour is not that of myrrh, bdellium or galbanum, and altogether it is very suggestive of frankincense that has been powdered and made into balls.[5]

Myrrh[6]

Myrrh, like frankincense, is a fragrant gum-resin and is obtained from the same countries as frankincense, namely, Somaliland and southern Arabia. It is derived from various species of *Balsamodendron*

[1] H. Schoff, notes to *The Periplus of the Erythraean Sea*, p. 218.
[2] H. Schoff, *op. cit.*, p. 289. [3] XII: 32.
[4] E. W. Lane, *op. cit.*, p. 194.
[5] A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, III, Appendix II, pp. 181–2.
[6] See also A. Lucas, *Journal of Egyptian Archaeology*, XXIII (1937), pp. 27–33.

and *Commiphora*, and occurs in the form of yellowish-red masses of agglutinated tears, often covered with its own fine dust; it is never white or green and so cannot be either the white[1] or green[2] incense referred to in the ancient records. In Breasted's translation of these records it is stated that myrrh was obtained from Punt (Fifth,[3] Eleventh,[4] Eighteenth,[5] Twentieth[6] and Twenty-fifth[7] Dynasties) and from Genebteyew[8] (Eighteenth Dynasty), which is in agreement with its known origin. Even the receipt of myrrh from Retenu[9] in western Asia (Eighteenth Dynasty) is not impossible, since it might readily have reached Retenu from Arabia.

Theophrastus, Dioscorides and Pliny have already been quoted for the statements that myrrh entered into the composition of certain Egyptian unguents, and Plutarch refers to the use of myrrh as incense in Egypt.[10] A late papyrus (257 B.C.) mentions Mendesian myrrh in small lead vessels.[11]

Myrrh has been identified by Reutter in ancient Egyptian perfumes[12] (undated), and specimens of gum-resin from certain royal and priestly mummies of the Eighteenth, Nineteenth, Twentieth and Twenty-first Dynasties respectively examined by the author were probably myrrh.[13] This identification was confirmed in one instance by Launoy.[14]

Satisfactory incense materials other than frankincense and myrrh are very few and must have been still fewer in ancient Egypt, since such substances as benzoin and camphor from the Far East and, in the earlier periods, the products of India were probably not then available. Speculation, however, as to what might have been employed is of little value and may be misleading, and only those materials will be mentioned for the use of which in Egypt there is some probability, and these are limited to galbanum, ladanum, and storax, which may now be described.

[1] J. H. Breasted, *op. cit.*, IV, 233, 239, 299, 344, 376.
[2] II, 572. [3] I, 161. [4] I, 429.
[5] II, 265, 274, 276, 277, 321, 486. [6] IV, 130, 210, 407.
[7] IV, 929. [8] II, 474. [9] II, 491
[10] *Isis and Osiris*, French trans., M. Meunier, p. 164.
[11] C. C. Edgar, *Papyri Zenon*, I, No. 59089.
[12] L. Reutter, *Analyses des parfums égyptiens*, in *Annales du Service*, XIII (1914), pp. 49–78.
[13] A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, pp. 26–9.
[14] R. Pfister, *Nouveaux textiles de Palmyre* (1937), p. 10.

Galbanum

This is a fragrant gum-resin generally occurring in masses of agglomerated tears and is of a light brownish-yellow to a dark brown colour, with often a greenish tint; it has a greasy appearance and, though usually hard, it may occasionally be of semi-solid consistency; it is a native of Persia and a product of various species of the umbelliferous plant *Peucedanum*, of which *P. galbaniflorum* is the most important. This is the only green incense material known to me, except that frankincense is green when freshly gathered[1] and even as found in commerce it may occasionally have a slight greenish tint. As there would not have been any difficulty in galbanum reaching Egypt from Persia in the Eighteenth Dynasty, this may well have been the green incense mentioned in the ancient records.[2] According to Dioscorides[3] and Pliny,[4] galbanum was one of the constituents of the Mendesian unguent, and it is mentioned in the Bible as entering into the composition of Jewish incense.[5] There is no record of galbanum having been found in ancient Egyptian graves.

Ladanum

This, unlike the other incense materials described, is a true resin and not a gum-resin; it occurs in commerce as dark brown or black masses, which are often viscid or easily softened by handling: it exudes naturally from the leaves and branches of various species of *Cistus* that grow in Asia Minor, Crete, Cyprus, Greece, Palestine, Spain and other parts of the Mediterranean region, though not at the present time in Egypt. Pliny states[6] that the Ptolemies introduced ladanum into 'the parts beyond Egypt,' the meaning of which is obscure.[7]

Newberry has recently suggested[8] that the ancient Egyptians were acquainted with ladanum as early as the First Dynasty. From purely theoretical considerations this is only what might be expected, since, even if ladanum were not an Egyptian product, it was abundant in countries bordering the Mediterranean with which Egypt had intercourse and from which it might easily have been obtained. No positive evidence, however, can be found for this early use. The earliest literary

[1] Bertram Thomas, *Arabia Felix*, p. 122.
[2] J. H. Breasted, *op. cit.*, II, 572. [3] I: 71. [4] XIII: 2.
[5] *Exodus*, XXX: 34 (Revised Version).
[6] XII: 37. [7] See p. 112.
[8] P. E. Newberry, in *Journal of Egyptian Archaeology*, XV (1929), p. 94.

references known to me for the use of ladanum in Egypt are in the Bible, where it is stated that certain merchants carried ladanum into Egypt from Gilead[1] and that Jacob sent ladanum to Egypt as a present to his son Joseph.[2] The date of this record is probably not earlier than the tenth century B.C. and possibly as late as the eight century B.C. Incidentally it may be noted that the sending of ladanum from Palestine to Egypt suggests that ladanum at that time was either not a product of Egypt or that it was not very plentiful. The next literary reference in date order that can be traced is the one already quoted from Pliny in the first century A.D. In modern times Lane states that it was customary for the Egyptian women of his day to chew ladanum to perfume their breath.[3]

So far as is known, the only instance of ladanum having been found in connexion with ancient Egypt is a specimen of Coptic incense of the seventh century from Faras near Wadi Halfa, which was examined by me and the results published some years ago.[4] This was a fragrant, black resin containing 31 per cent of mineral matter and is probably ladanum. A genuine specimen of ladanum of good quality analysed for comparison purposes yielded 80 per cent of resinous matter and 20 per cent of matter insoluble in alcohol.

Storax

Storax (Styrax) is a balsam obtained from the tree *Liquidambar orientalis*, belonging to the natural order *Hamamelideæ*, indigenous to Asia Minor. It is a turbid, viscid greyish liquid having an odour like benzoin and belongs to the same class of bodies, the distinguishing feature of which is that they contain either cinnamic or benzoic acid, storax containing the former. At one time, however, the name storax was applied to the solid resin obtained from *Styrax officinalis*, which somewhat resembles benzoin. Reutter has identified storax in Egyptian mummy material[5] and in ancient Egyptian perfumes,[6] both unfortunately undated. There is no evidence that 'gum-styrax, modern storax, was taken from trees in upper Egypt,' as stated by Rostovtzeff,[7]

[1] *Genesis*, xxxvii: 25 (Revised Version).
[2] *Genesis*, xliii: 11 (Revised Version).
[3] E. W. Lane, *op. cit.*, p. 194.
[4] A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, pp. 31–2.
[5] L. Reutter, *De l'embaumement avant et après Jésus-Christ*, pp. 49, 59.
[6] L. Reutter, *Analyses des parfums égyptiens*, in *Annales du Service*, XIII (1914), pp. 49–78.
[7] M. Rostovtzeff, *A Large Estate in Egypt in the Third Century, B.C.*, p. 178.

and the word translated by him as styrax is rendered as 'vegetable juice' by Edgar, who says[1] that Rostovtzeff's note on this word 'is based upon a misapprehension.'

Miscellaneous Incense Materials

Specimens of various miscellaneous materials of ancient Egyptian origin submitted as incense have been examined by me from time to time and may now be described. One of these was Coptic incense of the same date and from the same place as the ladanum already mentioned. This second specimen, however, was very different; it was in irregular-shaped pieces of a dark reddish-brown colour, translucent when freshly fractured, very resinous-looking and possessed a fragrant smell. On analysis it proved to be a true resin, as distinguished from a gum-resin, and therefore could not be frankincense, myrrh, galbanum or storax, and its colour was not that of ladanum; it was not identified.[2] A specimen of material found by Legrain at Karnak was dull and opaque in appearance, and on analysis proved to be a true resin mixed with 76 per cent of limestone dust. Although described by the finder as incense, it is suggested that it was a cementing material similar to that discovered at Karnak a few years later by Pillet,[3] and to that found by Montet at Tanis.[4]

A mixture of resin (or gum-resin) and natron was found in the tomb of Tut-ankhamun, which may have been incense, natron being sometimes used in incense.[5] The resin (or gum-resin, there was too little of the specimen available for this point to be determined) is in the form of very small tears and rods, the latter being 2 to 5 mm. long and 0.5 mm. in diameter; it is white on the outside from adhering natron and its own fine dust, but light yellowish-brown in the interior; it is largely, though not entirely, soluble in alcohol: it has not been identified, but it is certainly not myrrh and the appearance is not that of frankincense.[6]

[1] C. C. Edgar, *Zenon Papyri*, III, No. 59368, p. 113.

[2] A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, pp. 31–2.

[3] M. Pillet, *Annales du Service*, XXIV (1924), pp. 64–5.

[4] P. Montet, Découverte d'une nécropole royale à Tanis, *Annales du Service*, XXXIX (1939), p. 530.

[5] (*a*) British Museum, *Introductory Guide to the Egyptian Collections*, 1930, p. 5; (*b*) E. A. Wallis Budge, *The Literature of the Ancient Egyptians*, 1914, pp. 14, 38, 218.

[6] A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, III, Appendix II, p. 181.

That frankincense occurs in the Sudan has already been stated, but in addition there are also other materials that might be employed as incense, though whether they have been so used is unknown. I have examined two of these, one *Gafal* resin stated to be obtained from *Balsamodendron africanum* and the other the product of *Gardenia Thunbergia*. The *Gafal* resin was in the form of irregular-shaped masses, yellowish, light brown or dark brown in colour and generally translucent and very resinous-looking. The *Gardenia Thunbergia* product was also in irregular lumps, but very different in appearance from the *Gafal* resin; it varied in colour from a light yellowish-brown to black and was entirely opaque. Both materials are fragrant gum-resins and seem very suitable for incense purposes.

As already mentioned, resin is a very common material in ancient Egyptian graves of all periods, being a marked feature of Badarian and predynastic burials long before mummification was practised and also of early dynastic burials in cases where the body had not been mummified, either because the practice was not yet known, or because it had not become general.

This resin is always a true resin, as distinguished from gum-resins such as frankincense and myrrh, which latter are products of countries that are farther south and hotter than Egypt, whereas most true resins, and probably all those under discussion, are either from coniferous trees (cedars, pines, firs and spruces), or from species of *Pistacia* (chiefly *P. terebinthus*) that grow in countries more northerly and colder than Egypt and, considering the early connexions of Egypt with western Asia, where such trees are plentiful, this would seem a likely source from which these resins might have been obtained.

These resins, many of which are very similar in appearance, are usually without smell, though occasional specimens are fragrant: they are generally opaque and of a dull brown colour on the outside, but bright and resinous-looking in the interior: they give similar results on analysis and are probably largely, though not entirely, of one kind, the botanical source of which it has not been possible to determine. As these resins are of a date before mummification and also before the use of resin for varnish or as an adhesive or for making into personal ornaments and other objects,[1] except occasional small beads which have been found from predynastic

[1] See p. 444, where a list is given of resin objects found in the tomb of Tut-ankhamun.

times,[1] the most likely use seems to have been as incense, more particularly as there is no evidence that frankincense and myrrh were known before the dynastic period. As a rule, however, the smell produced when this resin is burned is not fragrant according to modern ideas, being very like burning varnish, though occasionally specimens have been examined that are aromatic.[2] If incense, this was the forerunner of the more sweet-smelling and probably much more rare and expensive frankincense and myrrh and, if not incense, then the almost entire absence in graves of one of the most commonly employed materials in the religion and magic of ancient Egypt remains unexplained. Possibly, too, even after frankincense and myrrh became known their use was restricted to special occasions on account of their rarity and price, a more easily obtained and cheaper material being employed for ordinary purposes and by the poorer people, which would explain the occurrence of this brown resin in the graves of all periods and of all ranks. The discussion of the botanical sources of these resins will be considered when dealing with the true resins employed at a later date and principally in connexion with mummification.[3]

Fragrant Woods

In connexion with perfume and incense the use of fragrant woods in ancient Egypt may be mentioned.

In the tomb of Tut-ankhamun there was a small red pottery jar containing cut pieces of plant stalks, which was inscribed ' perfume ' or ' substance used for perfuming.'[4]

Winlock reports ' small splinters of wood, which was doubtless originally aromatic ' of Eleventh Dynasty date from El Lahun,[5] and of the same date from Thebes he found ' little sticks of sweet-scented wood for perfumes.'[6]

The origin of this aromatic wood is not known, but scented woods occur in East Africa (Uganda and Kenya).[7]

[1] E. R. Ayrton and W. L. S. Loat, *The Predynastic Cemetery of El Mahasna*, pp. 11, 17, 27, 31.

[2] Ure (quoted by J. G. Wilkinson and S. Birch, *The Ancient Egyptians*, 1879, III, pp. 398–9) examined two specimens of resin, both of which were soluble in alcohol, but only one was soluble in turpentine.

[3] See p. 368 ff. [4] Kindly translated by Dr. Černý.

[5] H. E. Winlock, *The Treasure of El-Lahun*, p. 67.

[6] H. E. Winlock, *Bull. Met. Mus. of Art, New York, Egyptian Expedition, 1930–1931*, pp. 32, 35–6; Fig. 34.

[7] C. R. Metcalfe, *Bull. of Misc. Information*, No. 1, 1933, Royal Botanic Gardens, Kew.

CHAPTER VII

INLAID EYES[1]

Inlaid eyes were used in ancient Egypt for coffins, mummies, mummy masks, statues and statuettes, but no evidence has been found that they were ever used by the living. Dr. M. A. Murray, however, describing one particular eye in the Museum of University College, London, states[2] that 'The shape and size of the eye, as well as the fact that the edges are carefully rounded, show that it was for human use. Eyes for insertion in statues and coffins have sharp edges totally unlike this example.' This eye is glass and is all one piece; the eyeball is white with a blue border and the pupil black; there is no iris. The blue border, the absence of an iris and the poor workmanship make it most improbable that the eye was intended for a living person, as it would not match any human eye, and it seems much more likely that it is from a mummy.

Before the ancient imitation eyes are described, the visible parts of the human eye may be mentioned, and are as follows:—

Eyelids: the covers of the eyes formed of movable membrane which permits the eyes to be covered or uncovered at will. There are two eyelids, an upper and a lower one, to each eye.

Eyelashes: the fringes of hair that edge the eyelids.

Eyeball: the whole eye, or sphere, contained within the orbit, the white being that part of the outer, or sclerotic, coat of the eyeball that is usually seen.

Cornea: the circular, transparent, colourless front of the eye, through which the light enters, and which is continuous with the sclerotic coat, but projects a little beyond it, since it has a slightly greater convexity than the rest of the eyeball.

[1] This chapter has been taken in part from an article 'Inlaid Eyes in Ancient Egypt, Mesopotamia and India,' published by me in *Technical Studies*, VII, No. 1, July 1938, and from a previous article, 'Artificial Eyes in Ancient Egypt,' in *Ancient Egypt and the East*, December 1934, pp. 84–98, but considerable alterations and additions have been made.

[2] *Ancient Egypt and the East*, 1934, pp. 98–9.

Iris: the coloured annular curtain behind the cornea which expands and contracts, causing the pupil to dilate or narrow as the case may be.

Pupil: a circular opening in the middle of the iris that appears to be black because beyond it is the dark interior of the eye.

Canthus: the angle between the upper and lower eyelids; therefore there are two canthi to each eye.

Caruncle: a small red swelling at the inner angle only of the eyelids, just within the inner canthus. There is no caruncle in the outer canthus.

With very few exceptions, all the eyes in the Cairo Museum have been examined by me, as also many others. Naturally, it was not convenient to remove large objects from their cases for examination, but occasionally it was possible to get inside a case, or even to remove the case, leaving the object on the stand. Naturally, too, the eyes could not be taken out of the sockets and separated into their component parts and, therefore, a partial examination was all that was possible. Fortunately, however, there were many loose eyes that could be taken apart and examined in detail.

Much thought has been devoted to finding a good and simple system of classification with the minimum number of classes, and the course adopted has been to take as a guiding principle the technique and not the materials. Slight differences in technique, as well as differences in materials with the same technique, are regarded as variants of a class and not as separate classes; otherwise the number of classes would have been very large.

Predynastic Period

Simple inlaid eyes date from the predynastic period and often consist of white shell, ring beads.[1] Objects of this date in the Cairo Museum having inlaid eyes are: (*a*) a human figure with eyes inlaid in black material[2]; (*b*) a fish palette with one white inlaid eye, probably not a bead[3]; (*c*) a human figure in ivory with inlaid eyes of white ring beads[4]; and (*d*) a vase in the form of a gazelle with a white ring bead for one eye, the other eye being missing.[5] In the British Museum there is a predynastic figure of a woman carved in bone with inlaid eyes of lapis lazuli.[6] Similar simple eyes were also used at later

[1] W. M. F. Petrie, *Prehistoric Egypt*, p. 6, Pl. II; W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 10.

[2] No. J. 52839. [3] No. J. 57562. [4] No. J. 41228. [5] No. J. 66628.

[6] British Museum, *A General Introductory Guide to the Egyptian Collections*, 1930, p. 21, Fig. 6.

periods, for example, there is in the Cairo Museum a small ivory fish of Tenth or Eleventh Dynasty date, the eyes of which consist of small blue ring beads.[1]

Class I

This kind of eye is known from the Fourth Dynasty[2] to the Thirteenth Dynasty: it is an admirable imitation of the natural eye, of which it reproduces all the essential features (eyelids, eyeball, cornea, iris, pupil and caruncle) and is very much better than the eyes made at any other period, or by any other ancient people.

Eyelids: the outer edge of a narrow frame surrounding the eyeball, generally metal (copper or silver), but very occasionally faience or blackened limestone.

Eyelashes: none.

Eyeball: wedge-shaped with a rounded front for statues, statuettes, masks and anthropoid coffins, and flat for non-anthropoid coffins. The material is generally polished opaque quartz, but sometimes polished crystalline limestone, often Egyptian alabaster (calcite[3]) with a shallow circular depression drilled in the middle of the front to receive the cornea, which is fastened in place with an adhesive, sometimes resin.

Cornea: transparent rock crystal, rounded and polished at the front, but matt (like ground glass) at the back and edges.

Iris: there is no separate iris, but the effect of a brown iris is produced by a disc of dark brown resin placed behind the cornea, as dimly seen through the matt surface at the back. Sometimes the iris is grey, or partly grey and partly brown, and I have found by experiment that when the cornea is merely placed on the resin, and is not in absolute contact with it at every point, but is separated from it by a thin film of air, the appearance, as seen from the front, is grey, and is due almost entirely to the optical effect of the matt surface at the back of the cornea, but when the resin is in absolute and intimate contact with the cornea, the colour, as seen from the front, is brown.

[1] No. J. 54343.

[2] The Third Dynasty statue of Zoser in the Cairo Museum originally had inlaid eyes which have been gouged out.

[3] Sometimes the limestone is banded like alabaster (calcite), in which case undoubtedly it is alabaster, but sometimes it is without any special distinguishing mark, when it may be either alabaster or white marble, though generally alabaster. Since both these materials are crystalline limestone, this name may be applied correctly to either and is particularly appropriate when there is any uncertainty which of the two it is.

The majority of present-day Egyptians have brown irides, and it seems probable, therefore, that this also was the case anciently, hence brown irides are more likely than grey ones. If the original colour were brown, the cornea must have been placed in position when the resin was still in the viscous condition, before it cooled and became solid, since only in this manner could absolute contact between the cornea and the resin have been produced. If so, then the grey, or patches of grey, may be explained by assuming that in these cases the resin has shrunk, so that it no longer makes absolute contact with the cornea.

Pupil: a small circular recess drilled in the middle of the back of the cornea and filled with a plug of very dark brown or black resin, or sometimes a circular black spot painted on the resin behind the cornea; occasionally the pupil is absent.

Caruncle: a small red patch painted on the inner canthus, but sometimes on both the inner and outer canthi. That the Egyptians, who were usually such faithful copyists of nature, should have made the mistake of putting two caruncles, instead of only one, is extraordinary. Occasionally the caruncle is absent.

Examples

Squatting Scribe (*Fourth Dyn.*). Painted limestone, Cairo Museum.

Eyelids: copper, much corroded.

White[1]*:* quartz.

Cornea: rock crystal.

Iris: grey and blistered.

Pupil: a recess at the back of the cornea filled with very dark material.

Caruncle: none visible.

Maspero states[2] that 'the eyes are inlaid, the alabaster and crystal composing them are set in copper lids; a small splinter of ebony behind the crystal imitates the pupil . . .' It is most improbable that the cornea was taken out for the pupil to be examined, and, if not, there cannot be any evidence of the nature of the pupil, and it is much more probable that it is the dark-coloured resin such as was employed in the Middle Kingdom and not ebony.

Borchardt says[3] that the eyes are inlaid like those of the small seated statue described below, which represents the same person.

[1] The word 'white' is used instead of 'eyeball' when the eye is in position and only the front portion can be seen.

[2] G. Maspero, *Guide to the Cairo Museum*, trans. J. E. and A. A. Quibell, 1910, p. 54.

[3] L. Borchardt, *Statuen und Statuetten von Königen und Privatleuten*, I, No. 36.

Small Seated Statue (*Fourth Dyn.*). Painted limestone, Cairo Museum.
Eyelids: copper, much corroded.
White: quartz.
Cornea: rock crystal.
Iris: grey.
Pupil: a recess at the back of the cornea filled with very dark material.
Caruncle: none.
Borchardt says[1] that the eyelashes (*Wimpern*), meaning the eyelids (*Augenlider*), are metal, possibly copper; the eyeballs quartz; the iris, meaning the cornea, rock crystal and the pupil a dark-coloured wooden nail.

Rahotpe and Nofret (*Fourth Dyn.*). Painted limestone, Cairo Museum.
Eyelids: copper.
White: quartz.
Cornea: rock crystal.
Iris: partly brown and partly grey.
Pupil: recess at the back of the cornea filled with very dark material.
Caruncle: present in both canthi of both eyes.
Borchardt states[2] that the eyelashes (*Wimpern*), meaning the eyelids (*Augenlider*), are metal, probably copper; that the white is alabaster or bone; that the iris, meaning the cornea, is rock crystal, with apparently a brownish material underneath, and that the pupil is a dark brown wooden peg.
Danios Pasha, the finder of the statues, states[3] that the eyelids are bronze, which is most improbable at this date; that the eyeballs are white quartz with rose-coloured veining, evidently mistaking the painted caruncles for natural markings; and that the cornea is rock crystal with a shining nail underneath to represent the pupil.
Dr. M. Murray says[4] that the eyelids are copper; the white is polished limestone and the iris 'clear quartz painted at the back.'

Sheikh el Beled (*Fifth Dyn.*). Wood, Cairo Museum.
Eyelids: copper.
White: quartz.
Cornea: rock crystal.
Iris: grey.
Pupil: recess at the back of the cornea filled with very dark material.
Caruncle: none.
Maspero states[5] that 'The eyes were inlaid . . . They are made of a piece of opaque white quartz, with a frame of bronze surrounding it to imitate

[1] L. Borchardt, *op. cit.*, No. 35.
[2] L. Borchardt, *op. cit.*, Nos. 3 and 4.
[3] Danios Pasha, *Recueil de travaux*, VIII (1886), pp. 69–72.
[4] M. A. Murray, *Egyptian Sculpture*, p. 52.
[5] G. Maspero, *op. cit.*, p 52.

the lid; a small disc of transparent rock-crystal forms the iris, while a tiny spangle of polished ebony—not silver, as has been said too often—fixed behind the crystal imparts to it a life-like sparkle.' The eyelids are copper and not bronze; the rock crystal forms the cornea and not the iris and, although the eyes have not been taken apart for the examination of the pupil, it is most improbable that the dark material is ebony, for which no evidence is given.

Borchardt says[1] that the eyelashes (*Wimpern*), meaning the eyelids (*Augenlider*), are metal, probably copper; that the white is a white stone; that the iris, meaning the cornea, is rock crystal; and that the pupil is a wooden nail.

Baedeker rightly says[2] that 'the eyes consist of pieces of opaque white quartz with copper frames to imitate lids,' but is wrong when he states that 'small discs of rock-crystal form the pupil,' the rock crystal being the cornea.

Petrie refers to the 'eyeball of stone and crystal in a copper frame.'[3]

Bust of a Man (*Fifth Dyn.*). Wood, Cairo Museum.

Eyelids: copper.

White: crystalline limestone.

Cornea: rock crystal.

Iris: grey.

Pupil: none.

Caruncle: none.

Borchardt says[4] that the eyelashes (*Wimpern*), meaning the eyelids (*Augenlider*), are metal, probably copper; that the white is bone; that the iris, meaning the cornea, is rock crystal; and that the pupil is not visible.

Squatting Scribe (*Old Kingdom*).[5] Wood coated with painted plaster, in very bad condition. Store Room at Saqqara.

Eyelids: copper.

White: quartz.

Cornea: rock crystal.

Iris: light grey, but surface irregular with irregular brown lines.

Pupil: dark grey, consisting of a projection of the material behind the cornea that fits into a recess at the back of the cornea.

Caruncle: none.

Four Small Statues (*Fourth Dyn.*).[6] Limestone, Cairo Museum.

There are four similar statues, all of which have sockets for inlaid eyes. In two cases the sockets are empty; in a third case one socket is empty, but

[1] L. Borchardt, *op. cit.*, No. 34.
[2] K. Baedeker, *Egypt and the Sudan*, 1929, p. 90.
[3] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 33.
[4] L. Borchardt, *op. cit.*, No. 32.
[5] No number. [6] Nos. J. 72214–72217.

the other contains a corroded copper rim; the fourth statue has inlaid eyes, but as they are fastened in place with modern plaster, and as there are no copper rims, manifestly they are not in their original condition, and no record can be traced of what they were like when found. As they now are, the eyes consist of cornea and pupil only, the cornea being a disc of rock crystal, rounded and polished at the front and matt at the edges. Through this can be seen a small black pupil, which probably is painted at the back of the cornea.

Anthropoid Coffin of Sepa from El Barsha (Twelfth Dyn.). Cairo Museum.

Eyelids: limestone, artificially blackened.

White: crystalline limestone.

Cornea: rock crystal.

Iris: brown.

Pupil: recess at the back of the cornea filled with very dark material.

Caruncle: present in both canthi of both eyes.

Lacau[1] calls the eyeball white alabaster; the cornea rock crystal; the iris *un mastic brun*; and the pupil black.

Fifteen Loose Eyes (Middle Kingdom).

Three pairs of these eyes, from mummy masks, are all alike and are in the Cairo Museum.[2]

Eyelids: silver.

Eyeball[3]*:* wedge-shaped, opaque, white quartz with a circular depression drilled in the front to receive the cornea.

Cornea: rock crystal.

Iris: see below.

Pupil: a small circular recess in the middle of the back of the cornea filled with dark-coloured resin; see below.

Caruncle: Nos. 52945–52946, no caruncle visible, but the eyeballs are blackened by silver compounds from the corroded eyelids, which might mask the red of the caruncles. No. 52947 has no caruncle. No. 52948, caruncle in both canthi. No. 52949, no caruncle visible, but the eyeball is blackened by silver compounds, which might mask the red of the caruncle. No. 52950, possible trace of red in the inner canthus.

No. 52945. The iris is partly grey and partly brown. The cornea was not removed, but behind it there is almost certainly a dark brown resin, such as is present in No. 52948.

The pupil is a small cylindrical projection arising from, and forming part of, the flat surface of the resin behind the cornea, and it fills the recess at the back of the cornea: it has generally a very dark, or black, top and what

[1] P. Lacau, *Sarcophages antérieurs au Nouvel Empire*, I, No. 28084, p. 199.

[2] E. Vernier, *Bijoux et Orfèvreries*, Nos. 52945–52950.

[3] The word 'eyeball' is used instead of 'white' when the eye is loose and the whole, or the greater part, of the eyeball can be seen.

looks like a white circumference. Vernier explains this[1] by supposing that the whole surface of the dark brown resin, except the top of the projection forming the pupil, was coated with a white material, which he states was undoubtedly plaster (i.e. gypsum plaster), that he thinks has decomposed and largely disappeared. Gypsum plaster, however, is a very permanent material and does not easily decompose and disappear and the few tiny white particles now to be seen in some of the small cavities of the resin of No. 52948 may be merely limestone dust that has accidentally found its way in since the cornea was lost, and no white particles can be found in any of the other eyes. In my opinion, the apparent white of the circumference of the projection forming the pupil is merely an optical effect due to the manner in which the light is reflected from the sides of the recess.

No. 52946. The iris is grey; the pupil has a grey top and apparently a white circumference. The material fastening in the cornea manifestly is modern.

No. 52947. The iris is grey with patches of brown; the pupil is black.

No. 52948. The cornea is missing and the cavity in the eyeball originally covered by the cornea is very deep, much more than usual, and is filled with dark brown resin. Vernier points out[1] that this filling is friable (*sans beaucoup de résistance*) and that it must have been introduced in a viscous (*malléable*) condition. In the absence of the cornea, the iris and pupil are also necessarily missing.

No. 52949. The cornea is loose and can be removed for examination, which was done. The sides and bottom of the depression in the eyeball, which is not nearly so deep as in No. 52948, are very irregular and show that the quartz has been drilled and chipped out, the marks of a tubular drill being visible. It is practically certain that a filling of dark brown resin similar to that present in No. 52948 originally existed in this case also (and probably exists, too, in the other four eyes, though its presence cannot be proved without taking the eyes to pieces), having been put into the cavity to hide the uneven surface of the quartz and to form the coloured iris, but the only evidence of this resin that now remains is a little (forming the pupil) in the hole in the recess in the cornea, and a patch adhering to the back of the cornea round the mouth of the recess.

No. 52950. The iris is grey with patches of brown, and the pupil is black. Vernier wrongly identifies the opaque quartz eyeballs in these eyes as the cornea and says[2] *C'est la pierre blanche qui joue le rôle de cornée.*

One Loose Eye. No. 52848. Cairo Museum.

This is stated by Vernier to be from Dahshur[3]; it is probably from the tomb of Princess Nub-hetepti-khred.

[1] E. Vernier, *op. cit.*, p. 313.
[2] E. Vernier, *op. cit.*, pp. 312–3.
[3] E. Vernier, *op. cit.*, p. 284.

Eyelids: faience, probably once blue, but now much deteriorated and discoloured.

Eyeball: wedge-shaped quartz.

Cornea: rock crystal.

Iris: grey.

Pupil: circular black spot below the cornea, but whether painted or the usual recess filled with black material cannot be determined without removing the cornea, though probably painted.

Caruncle: present in the inner canthus and probably also in the outer canthus.

Vernier says[1] that the eyelids are *céramique vert brun*; the eyeball *céramique d'un blanc ivoirin*; the *prunelle* rock crystal; and that the depression in the centre of the eyeball for the insertion of the cornea *joue le rôle d'iris*.

Six Loose Eyes. These are two pairs and two single eyes from Lisht kindly given to me by Mr. Ambrose Lansing of the Metropolitan Museum of Art, New York, and are of Old Kingdom date.

The Two Pairs. Identical except in size, one pair being smaller than the other.

Eyelids: missing.

Eyeball: wedge-shaped alabaster, in the front of which a circular depression has been drilled with a tubular drill to receive the cornea, and in this depression there is a disc of dark brown resin, which from the manner in which it fits must have been introduced in the molten condition.

Cornea: a disc of transparent rock crystal, slightly convex and polished on the outer surface and flat and matt on the inner surface and matt round the edges.

Iris: grey with brown patches in one pair of eyes and entirely grey in the other pair, the brown in one eye, in which the cornea was removed for examination, being due to a little resin from the disc behind the cornea adhering firmly to the back of the cornea and doubtless a similar condition accounts for the brown patch in the other eye.

Pupil: a circular spot painted in black on the disc of resin, a little to one side of the middle.

Caruncle: remains of caruncles are present in both canthi of both pairs of eyes.

Single Eye.

Eyelids: missing.

Eyeball: wedge-shaped alabaster in the middle of the front of which a depression has been drilled by means of a tubular drill to receive the cornea.

Cornea: a disc of transparent rock crystal, slightly convex and polished on the upper surface; flat and matt on the under side and matt round the edges.

[1] E. Vernier, *op. cit.*, p. 284.

Iris: grey; there is a disc of dark brown resin behind the cornea.

Pupil: a small circular recess drilled in the middle of the back of the cornea and filled with resin projecting from the surface of the disc.

Caruncle: present in the inner canthus.

Single Eye. This is very tiny and probably from a small statuette.

Eyelids: silver.

Eyeball: wedge-shaped crystalline limestone.

Cornea: rock crystal.

Iris: grey.

Pupil: none.

Caruncle: none.

Pair of Eyes (Middle Kingdom). Probably from non-anthropoid coffin; Cairo Museum.[1]

Eyelids: missing.

Eyeball: flat crystalline limestone with a circular depression drilled in the middle of the front to receive the cornea, at the bottom of which there is a small amount of brown powder (not nearly filling the depression), which is not resin, but contains organic matter and has not been identified.

Cornea: rock crystal.

Iris: brown from the brown powder as seen through the matt surface at the back of the cornea.

Pupil: the usual recess for the pupil has been drilled in the middle of the back of the cornea, but is empty.

Caruncle: present in both canthi of both eyes.

Hathor Heads (Middle Kingdom). Cairo Museum.

Two mirror handles having Hathor heads with inlaid eyes.

Eyelids: silver.

White: not determined.

Cornea: rock crystal.

Iris: grey.

Pupil: recess at the back of the cornea filled with dark material.

Caruncle: none.

No. 52663. The eyes on one side of the mirror have only the white left, which Vernier says[2] is white quartz and the *prunelle* rock crystal. Brunton, who found the mirror, states[3] that 'The eyes are of white paste, in two pieces, set in silver sockets with pupils of crystal.'

No. 53105. One eye is missing and the other is very corroded. Vernier gives no details,[4] but Bénédite says[5] that the eyelids are silver, the white

[1] Nos. $\frac{21}{25}|\frac{11}{2}$ A and B.

[2] E. Vernier, *op. cit.*, No. 52663.

[3] G. Brunton, *Lahun*, I, p. 36.

[4] E. Vernier, *op. cit.*, No. 53105.

[5] G. Bénédite, *Miroirs*, No. 44089.

(which he calls the cornea) ivory, and the *prunelle* transparent quartz with a small hole at the bottom to represent the pupil.

Statue of King Hor (Thirteenth Dyn.). Wood; Cairo Museum.

Eyelids: the eyelids (if any) of both eyes are covered thickly with a soft black material, certainly modern, probably used for fixing the eyes into the sockets, which prevents the nature of the eyelids from being determined; de Morgan says that they are gilt.[1]

White: quartz.

Cornea: rock crystal.

Iris: the colour of the right iris is brown with horizontal markings, possibly being the wood at the back of the socket seen through the cornea; the left iris is grey.

Pupil: the right pupil is missing; the left pupil is a black spot probably painted on the material behind the cornea.

Caruncle: none.

One plate in de Morgan's report[2] describing the finding of this statue shows it with certainly the right eye missing and possibly also the left, while another plate[3] shows both eyes. At the present time there are two eyes, but the right eyeball is slightly whiter than the left, which suggests a modern addition, and one of the Museum employees told me that the right eye was put in by the late Mr. A. Barsanti. If so, I suggest that possibly an ancient eyeball and cornea, not belonging to the statue, may have been used.

Borchardt says[4] that the right eye is modern and that only the white and the transparent iris (meaning the cornea) of the left eye are ancient.

Statuette of King Hor (Thirteenth Dyn.). Wood, much broken; Cairo Museum.

Eyelids: silver, corroded and blackened, not copper as previously stated by me.[5]

White: crystalline limestone.

Cornea: rock crystal.

Iris: grey and blistered.

Pupil: none.

Caruncle: none.

The finder, de Morgan, says[6] that the eyelids are silver and that the eyes are quartz. Borchardt states[7] that the eyelashes (*Wimpern*), meaning the

[1] J. de Morgan, *Fouilles à Dahchour, mars–juin, 1894*, p. 91.
[2] J. de Morgan, *op. cit.*, Pl. xxxiii.
[3] J. de Morgan, *op. cit.*, Pl. xxxv.
[4] L. Borchardt, *op. cit.*, No. 259.
[5] A. Lucas, Artificial Eyes in Ancient Egypt, *Ancient Egypt and the East*, 1934, p. 90.
[6] J. de Morgan, *op. cit.*, p. 95.
[7] L. Borchardt, *op. cit.*, IV, No. 1163.

eyelids (*Augenlider*), are metal; that the white is white quartz and that the pupil, meaning the cornea, is transparent.

Mask of King Hor (*Thirteenth Dyn.*). Wood; Cairo Museum. The eyes are in very bad condition.

Eyelids: metal, probably copper; now much corroded.

White: crystalline limestone.

Cornea: rock crystal (one is missing).

Iris: grey.

Pupil: none visible.

Caruncle: none visible.

The finder, de Morgan, says[1] *yeux de pierre, sertis de bronze.* Lacau calls the white of the eye alabaster, and the rock crystal *le cristallin*,[2] i.e. the crystalline lens, whereas it is the cornea.

CLASS II

This is the largest and most usual class of eye and it is neither so elaborate nor so effective as that of Class I. It consists generally of eyelids, eyeball, pupil and caruncle only, with occasionally eyelashes, and dates certainly from as early as the Fifth Dynasty to as late as Roman times, though the nature of the materials used varied considerably at different periods.

The pupil of these eyes, which generally is very large, is often called the iris, or iris and pupil combined, but in ancient Egypt, although the iris of the natural eye occasionally may have been black, probably it was usually brown, like the majority of the present-day Egyptian irides, and when a definite and separate iris is represented in an artificial eye, whether inlaid or painted, it is never black, so far as is known, but always either brown[3] or grey.[4] The grey, except when painted, most probably was brown originally, and when painted it is always of very late date, namely of the Graeco-Roman period, and hence may represent the iris of someone who was not an Egyptian, or not wholly Egyptian. Since, therefore, it was the pupil only of the Egyptian eye that was black, to call the black disc in the middle of the eyeball the iris is wrong.

[1] J. de Morgan, *op. cit.*, p. 98, Fig. 229 (p. 99).

[2] P. Lacau, *op. cit.*, II, No. 28107, p. 85.

[3] Examples of painted eyes in the Cairo Museum with brown irides are No. 28073 (P. Lacau, *Sarcophages antérieurs au Nouvel Empire*, I, p. 165); Nos. 33132, 33133, 33134, 33272 (C. C. Edgar, *Graeco-Egyptian Coffins, Masks and Portraits*), and Nos. $\frac{20}{19}|\frac{8}{4}$ and $\frac{18}{19}|\frac{8}{4}$.

[4] Painted grey irides occur in No. 33206 (Edgar, *op. cit.*) and in Nos. $\frac{20}{19}|\frac{8}{2}$ and J. 41097.

Eyelids: the outer edge of a thin frame surrounding the eyeball, which is usually copper, though occasionally silver, until the Eighteenth Dynasty, during which period it may be copper, bronze,[1] or glass, with sometimes gold for royal eyes, after which date glass was the usual material employed.

Eyelashes: only rarely represented and then always a prolongation of copper eyelids having the edges serrated.

Eyeball: generally wedge-shaped with convex front for statues, statuettes, mummies, masks and anthropoid coffins until the Graeco-Roman period, during which time the white[2] was often no longer part of a sphere, but a flat inlay with a slightly rounded outer surface, a technique similar to that used for non-anthropoid coffins of all periods. The material of the eyeball was usually crystalline limestone until the Graeco-Roman period, though occasionally white opaque quartz, glass, bone or other substance; and glass during the Graeco-Roman period, There is a hole, or flattened area, in the middle of the front of the eyeball, or white, to receive the pupil, which was fastened in place with an adhesive.

Cornea: usually none.

Iris: usually none.

Pupil: a large disc of black material attached to the front of the eyeball, or white,[2] usually obsidian, with the occasional use of black resin, black limestone (either naturally black or artificially blackened), black glass, or other black material until the Graeco-Roman period, during which generally it was black glass, but occasionally painted. Although the nature of the earlier material has not been proved by analysis to be obsidian, there is a considerable amount of circumstantial evidence that it is. Thus, it has all the appearance of obsidian, which was well known in ancient Egypt and had been employed for various purposes from predynastic times, and the alternative would be black glass, the use of which before the New Empire would be most improbable. Further, in those pupils which it has been possible to examine closely, the numerous small air bubbles that are such a constant feature of ancient Egyptian glass, are absent as are also all signs of the surface corrosion that is so frequently found in ancient Egyptian glass and in some of the glass eyes of Graeco-Roman date. The surface also

[1] It is usually impossible to distinguish between copper and bronze without a chemical analysis, which, of course, frequently cannot be made.

[2] The word 'white' is used instead of 'eyeball' when the eye is in position and only the front portion can be seen.

bears fine lines caused by the abrasive powder used for grinding and polishing, whereas similar pupils of black glass are generally, if not always, moulded.

Caruncle: usually a small red patch painted in the inner canthus, but sometimes in both canthi.

Examples

Kneeling Statuette (*Fifth Dyn.*). Limestone painted. Cairo Museum.
Eyelids: copper.
White: crystalline limestone.
Pupil: obsidian.
Caruncle: none.
Borchardt says[1] that the eyelashes (*Wimpern*), meaning the eyelids (*Augenlider*), are metal, probably copper; the white a white stone and the pupil black stone.

Pepi Statues (*Sixth Dyn.*). Copper. Cairo Museum.
Eyelids: none.
White: crystalline limestone.
Pupil: obsidian.
Caruncle: no evidence.
Quibell and Green state[2] that 'The pupil, a disc of black stone, probably obsidian, is set in an eyeball of white limestone.' Petrie refers to the 'white limestone eye of the statue,'[3] probably meaning the large statue, and Wainwright says[4] that 'The use of obsidian as an inlay representing the pupil and iris of the human eye began with the Pepi statues of the VIth. dynasty.'[5]

Figure of Teti (*Sixth Dyn.*)[6] in a fragment of low relief sculpture (limestone) from his mortuary chapel at Saqqara. Cairo Museum.
Eyelids: copper.
White: crystalline limestone.
Pupil: almost certainly obsidian.
Caruncle: none.

Two Loose Eyes (*Old Kingdom*).[7] From a non-anthropoid coffin found at Zawyet el Amwat. Cairo Museum.
Eyelids: copper.
Eyeball: flat, hard, crystalline limestone.

[1] L. Borchardt, *op. cit.*, No. 119.
[2] J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 46.
[3] W. M. F. Petrie, The Portraits, *Ancient Egypt*, 1915, p. 48.
[4] G. A. Wainwright, Obsidian in Ancient Egypt, *Ancient Egypt*, 1927, p. 89.
[5] The Fifth Dynasty eyes mentioned above are earlier.
[6] No. J. 39924. [7] No. J. 51922.

Pupil: obsidian.
Caruncle: none.

Non-anthropoid Coffin (Ninth to Eleventh Dyns.).[1] From Asyut. Cairo Museum.
Eyelids: copper.
White: banded alabaster.
Pupil: obsidian.
Caruncle: none.

Inner Coffin (non-anthropoid) of Amenemhet, Prince of Hermopolis. Cairo Museum. One of the eyes is in place,[2] but the other is loose and is exhibited separately.[3]
Eyelids: copper (one missing).
Eyeball: flat crystalline limestone.
Pupil: obsidian.
Caruncle: present in both canthi.

Outer Coffin (non-anthropoid) of Amenemhet. Cairo Museum. The eyes are not in position, but are exhibited separately.[4]
Eyelids: missing.
Eyeball: flat, crystalline limestone.
Pupil: plano-convex discs of limestone covered on both sides with a layer of black resin, which is called 'bitumen' in the Museum register, but I have tested it and it is resin and not bitumen. Lacau says[5] that the eyelids are metal; the eyeballs are alabaster and the iris and pupil combined are polished black stone.
Caruncle: present in both canthi.

Inner and Outer Coffins (non-anthropoid) of Prince Mesehti from Asyut (Middle Kingdom). Cairo Museum.
Eyelids: copper.
White: almost flat crystalline limestone.
Pupil: black limestone.
Caruncle: none visible.
Lacau says[6] that the eyelids are metal; the eyeballs alabaster; and the '*prunelle*' black stone.

Two Statues from Asyut (Middle Kingdom).[7] Wood. Cairo Museum.
Eyelids: copper.
White: crystalline limestone.

[1] No. J. 36318.
[2] P. Lacau, *op. cit.*, II, No. 28091, Pl. XIII.
[3] No. $\frac{2}{2}\frac{1}{5}\left|\frac{1}{7}\right.$; No. J. 34289.
[4] No. J. 34310.
[5] P. Lacau, *op. cit.*, II, No. 28092, p. 63.
[6] P. Lacau, *op. cit.*, Nos. 28118–28119, pp. 128, 133.
[7] Nos. J. 36283, 36284.

Pupil: black limestone.
Caruncle: none.

Small Bust from Karnak (Middle Kingdom).[1] Limestone. Cairo Museum.
Eyelids: copper.
White: crystalline limestone.
Pupil: obsidian.
Caruncle: none.

Twenty-two Loose Eyes (Middle Kingdom), as follows:
Seven Eyes (three pairs and one single),[2] mostly, if not all, from El Bersha.[3] Cairo Museum.
Eyelids: missing in two pairs; metal, probably copper, in one pair and in the single eye, the metal being much corroded in one case.
Eyeball: wedge-shaped crystalline limestone in all cases.
Pupil: obsidian in all cases. In two pairs one pupil is missing in each case; in one pair and in the single eye the pupils probably do not belong.
Caruncle: in one pair there are the remains of a caruncle in the outer canthus of one eye; in the other two pairs and in the single eye a caruncle is present in both canthi.

Single Eye.[4] Probably from El Bersha. Cairo Museum.
Eyelids: missing.
Eyeball: almond-shaped with rounded edges. The material is almost certainly odontolite (bone-turquoise) and not crystalline limestone, as previously reported by me,[5] although, like limestone, it is readily and entirely soluble with effervescence in hydrochloric acid. It gives a negative result when tested for copper, has a specific gravity of 2.8 and agrees in appearance with genuine odontolite, with which I have directly compared it. The Museum register describes it as green-coloured ivory (*ivoire verdi*).
Pupil: obsidian, which does not fit well, and may not belong.
Caruncle: none.

Single Eye from Abusir el Malaq.[6] Cairo Museum.
Eyelids: metal, probably copper.
Eyeball: wedge-shaped banded alabaster.
Pupil: black resin.
Caruncle: none.

[1] No. J. 64911.
[2] Nos. $\frac{21}{25}|\frac{11}{3}$, $\frac{21}{25}|\frac{11}{4}$, $\frac{21}{25}|\frac{11}{5}$, $\frac{21}{25}|\frac{11}{8}$, $\frac{21}{25}|\frac{11}{6}$.
[3] Ahmed Kamal, Fouilles à Deir-el-Barsheh, *Annales du Service*, II (1901), pp. 17, 32, 212, 217.
[4] No. J. 34317.
[5] A. Lucas, Artificial Eyes in Ancient Egypt, *Ancient Egypt, and the East*, 1934, p. 91.
[6] No. J. 49474.

Eleven Loose Eyes from Lisht.[1] These were kindly given to me by Mr. Ambrose Lansing, of the Metropolitan Museum of Art, New York.

These eyes are all practically alike, both in technique and also in respect to materials, and differ only in size. There are three pairs and five single eyes, one of which latter is larger than the rest and is probably from an anthropoid coffin, and another is very small and manifestly from a small statuette.

Eyelids: missing, except in the small eye, in which they are copper.

Eyeball: wedge-shaped alabaster (calcite).

Pupil: eight are obsidian and three are missing. Underneath the pupil in seven cases certainly and probably in nine, there is a black material composed of a mixture of whiting and resin coloured with carbon, and used evidently partly as an adhesive and partly to enhance the black of the translucent obsidian. The two exceptions are the large coffin eye and the small statuette eye, the former having no trace of this black material, the cavity for the pupil being a hole through the eyeball without any bottom, and the latter not having been taken to pieces for examination.

Caruncle: three pairs and three single eyes have caruncles in both canthi; one single eye has a caruncle only in the inner canthus, and one single eye (the very tiny one) has not any caruncle.

Two Loose Eyes from Dahshur (Middle Kingdom).[2] Cairo Museum.

Eyelids: none.

Eyeball: wedge-shaped alabaster.

Pupil: obsidian: in one case (No. 52850) there is a layer of dark brown resinous material under the pupil.

Caruncle: none.

Coffins of Senebtisi (Twelfth Dyn.).

These are in the Metropolitan Museum of Art, New York, and have not been examined by me. Mace and Winlock state[3] that the eyes of the outer coffin are of 'stone'; that those of the middle coffin 'were made up of almost flat sheets of stone, obsidian for the pupils and opaque calcareous stone for the whites, the latter stippled red in the corners. The pieces were fastened together with a blackish gum and set in tray-like wooden frames . . . the edges of which represented the eyelids' and that the eyes of the anthropoid coffin had 'polished obsidian pupils, whites of calcareous stone stippled red in the corners and silver frames of which the edges project to represent the eyelids.'

[1] These were previously stated by me to consist of four pairs and three single eyes (A. Lucas, *Ancient Egypt and the East*, 1934, p. 92), but on further examination it is now believed that there are only three pairs, the rest being single eyes.

[2] E. Vernier, *op. cit.*, Nos. 52849 and 52850.

[3] A. C. Mace and H. E. Winlock, *The Tomb of Senebtisi at Lisht*, pp. 23, 30, 40.

Hathor Head (*Middle Kingdom*). Cairo Museum.

The head is on a mirror handle and has a double face with inlaid eyes.

White: probably crystalline limestone.

Pupil: in one pair of eyes the pupils are missing; in the other pair the nature of the material was not determined, but it is dull black and not either obsidian or glass.

Caruncle: none.

Bénédite says[1] that the white is crystalline limestone and that the pupils are *pastilles noires*.

Non-anthropoid Coffin of King Hor (*Thirteenth Dyn.*). Cairo Museum.

Eyelids: copper.

White: flat crystalline limestone.

Pupil: obsidian.

Caruncle: none.

Lacau states[2] that the eyeballs are alabaster, very white and polished, and that the pupils are black stone, possibly obsidian.

Anthropoid Coffin of Queen Aahhotep[3] (*Eighteenth Dyn.*). Cairo Museum.

Eyelids: gold.

White: crystalline limestone.

Pupil: obsidian.

Caruncle: none.

Anthropoid Coffins of Yuya (*Eighteenth Dyn.*). Cairo Museum.

There are three coffins, the eyes of all of which appear similar, though the materials are not alike.

Eyelids: blue glass.

White: innermost coffin, white opaque quartz; middle and outermost coffins, crystalline limestone.[4]

Pupil: obsidian.

Caruncle: inner and outer coffins, caruncle in inner canthus only; middle coffin, no caruncle.

Quibell states[5] that the eyelids are blue glass, the eyeballs marble and the pupils black glass.

Anthropoid Coffins and Mask of Thuyu (*Eighteenth Dyn.*). Cairo Museum.

There are two coffins only.

Eyelids: blue glass.

White: crystalline limestone.[4]

[1] G. Bénédite, *op. cit.*, No. 44035.

[2] P. Lacau, *op. cit.*, No. 28100, p. 77.

[3] No. J. 4663.

[4] Tested since last described (A. Lucas, *Ancient Egypt and the East*, 1934, pp. 92–3).

[5] J. E. Quibell, *Tomb of Yuaa and Thuiu*, Nos. 51002, 51003, 51004, 51006, 51007, 51009, pp. 4, 5, 10, 20, 23, 28.

Pupil: obsidian.

Caruncle: present in inner canthus only.

Quibell states[1] that the eyelids are blue glass; the whites white marble and the pupils black glass. With reference to the mask he says 'a curious point is that there is a green faience backing to the white of the eye, invisible outside, inside nearly filling the space inside the blue glass.' This I have not examined.

Anthropoid Coffins and Mask of Tut-ankhamun (Eighteenth Dyn.). Cairo Museum, except the outermost coffin, which is in the tomb. The appearance of the eyes of all three coffins and the mask is similar, though the materials are different.

Eyelids: coffins, blue glass; mask, lapis lazuli.

White: when the innermost coffin was first uncovered the eyeballs were seen to be badly decomposed and they fell to pieces when the coffin was moved. They were crystalline limestone, which probably had been acted upon by the volatile acids derived from the fatty matter forming part ot the black anointing material that had been poured in large amount over the coffin, though not on the face. I believe that I tested the whites of the eyes of the other two coffins and found that they were crystalline limestone, but no note of this can be traced, and they cannot now easily be examined. The whites of the eyes of the mask are quartz.[2]

Pupil: obsidian.

Caruncle: innermost (gold) coffin, no caruncle noticed; middle and outermost coffins, not noted, and cannot now easily be examined; mask, caruncle in both canthi of both eyes.

Carter states in one place[3] that the eyeballs of the outermost coffin are aragonite, and in another place[4] that they are calcite and that the pupils are obsidian.

Anthropoid Canopic Coffins of Tut-ankhamun. Cairo Museum.

Eyelids: blue glass.

White: the eyes of one coffin are missing; the nature of the material of the other three has not been determined.

Pupil: the eyes of one coffin are missing and those of the other three are probably obsidian.

Caruncle: none.

Two Large Statues of Tut-ankhamun. Cairo Museum.

Eyelids: gold.

White: crystalline limestone.

[1] J. E. Quibell, *op. cit.*, p. 28.
[2] Tested since last described (A. Lucas, *op. cit.*, p. 93).
[3] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 52.
[4] Howard Carter, *op. cit.*, p. 247.

Pupil: obsidian.
Caruncle: present in both canthi of both eyes.

Small Statuettes of Human Figures from the Tomb of Tut-ankhamun.[1] Cairo Museum.

There are altogether twenty-six statuettes with inlaid eyes, one being alabaster and the rest wood gilt. It was previously stated by me[2] that the eyeballs of six of these statuettes were crystalline limestone and the pupils almost certainly obsidian. I have now examined the eyes of all the statuettes, so far as was possible, with the result that in twenty-five instances the white is believed to be opaque white glass and probably in many, if not in all, there is no eyeball, the white being represented by two flat triangular pieces of glass, slightly rounded at the front and inlaid in the corners of the sockets. The pupils are probably obsidian, though black glass is not entirely excluded. The eyelids are metal, either copper or bronze, with one example of gold.[3] In one instance[4] the technique is entirely different and this, therefore, falls into another class. In eighteen cases there are caruncles in both canthi of both eyes; in one case there is a caruncle in the inner canthus only; in three cases the caruncle is absent, and in three cases the eyes are too dirty for the presence or absence of caruncle to be ascertained. Carter states[5] of some of these statuettes that ' their eyes are inlaid with obsidian, calcite, bronze and glass.'

Chariot of Tut-ankhamun. Cairo Museum.

There are four small inlaid eyes on one of the chariots, two being inside the body of the chariot and two outside.
Eyelids: blue glass:
White: white opaque glass.
Pupil: black glass.
Caruncle: none.

Canopic Jars from the so-called Tomb of Queen Tiy (Eighteenth Dyn.). Cairo Museum.

There are three jars only (alabaster), the eyes of two of which are missing; those of the third jar are as follows:
Eyelids: blue glass.
White: white opaque glass.
Pupil: black glass.
Caruncle: present in both canthi of both eyes.

[1] Including gods and goddesses in human form.
[2] A. Lucas, *op. cit.*, p. 93. [3] No. J. 60731.
[4] Ahi holding Hathor emblem (No. J. 60732); this is one of a pair, the other (No. J. 60731) having normal Class II eyes.
[5] Howard Carter, *op. cit.*, III, p. 52.

Anthropoid Coffin of Hat-aai (Eighteenth Dyn.).[1] Cairo Museum.
Eyelids: copper.
White: crystalline limestone.
Pupil: obsidian.
Caruncle: present in inner canthus.
Daressy states[2] *yeux incrustés en pierre, sertis en bronze.*

Three Anthropoid Coffins of Maherpra (Eighteenth Dyn.).[3] Cairo Museum.
Eyelids: one pair not examined; one pair metal (probably copper) and one pair black, or blackened, limestone.
White: one pair not examined; two pairs crystalline limestone, one being banded alabaster (calcite).
Pupil: one pair not examined; two pairs obsidian.
Caruncle: one pair not examined; one pair has a trace of a caruncle in the inner canthus, and one pair is without caruncle.
Daressy says[4] of one of the coffins *les yeux incrustés de jaspe blanc et noir*; of another *les yeux en pierre noire et blanche sertis du bronze* and of the third *les yeux sont en jaspe blanc et noir et enchassés dans du bronze.*

Two Anthropoid Coffins of Queen Meryet-Amun (Eighteenth Dyn.). Cairo Museum.
Winlock, who found these coffins, describes the eyeballs as alabaster and the pupils as obsidian,[5] which, as seen through the glass of the case, they appear to be; the eyelids are blue glass much corroded. Winlock makes no mention of the eyelids of the outer coffin, but those of the inner coffin he says[5] are blue glass 'restored after the robbery.' No caruncles can be seen.

Anthropoid Coffin of Seti I (Nineteenth Dyn.).[6] Cairo Museum.
Eyelids: blue glass.
White: crystalline limestone.
Pupil: obsidian.
Caruncle: present in inner canthus.
Daressy says[7] *Les yeux incrustés d'émail blanc et noir.*

Upper Part of Wooden Statue of Woman (Nineteenth Dyn.). British Museum.
This has been described by Shorter,[8] who kindly allowed me to examine it. The interest is in the use of bone for the white.

[1] No. J. 31378.
[2] G. Daressy, *Annales du Service*, II (1901), p. 3.
[3] Nos. J. 33830, 33831, 33833.
[4] G. Daressy, *Fouilles de la Vallée des Rois*, pp. 4–7.
[5] H. E. Winlock, *The Tomb of Meryet-Amun at Thebes*, pp. 18, 20.
[6] No. J. 26213. [7] G. Daressy, *Cercueils des chachettes royales*, No. 61019.
[8] A. W. Shorter, *British Museum Quarterly*, IX (1935), p. 92.

Eyelids: none.
White: bone.
Pupil: missing.
Caruncle: none.

Three Bronze Statuettes of Divinities (Late Egyptian period). Cairo Museum.
Eyelids: remains of blue glass in two cases; no eyelids in third case.
White: crystalline limestone.
Pupil: missing in all three cases.
Caruncle: none.
Daressy calls[1] the material of one pair stone or enamel, that of another pair jasper, and says of the third pair merely that they are inlaid.

Single Loose Eye (Late Egyptian period).[2] Cairo Museum.
Eyelids: dark grey, fine-grained, soft stone, probably steatite.
Eyeball: white opaque glass.
Pupil: black glass.
Caruncle: none.

Three Loose Eyes from Late Egyptian period.[3] From Abusir el Malaq. Cairo Museum.
Eyelids: metal, either copper or bronze.
Eyeball: banded alabaster (calcite).
Pupil: two missing, the third being dark brown resin fastened to the flattened front of the eyeball.
Caruncle: not noted.

Two Anthropoid Coffins of Petosiris (Late Egyptian period). Cairo Museum.
Outer Coffin: the eyes are loose[4] and not on the coffin, which is not in the Museum.
Eyelids: metal, copper or bronze.
Eyeball: opaque white quartz.
Pupil: missing.
Caruncle: none.
Inner Coffin.[5]
Eyelids: blue glass, much decayed.
White: opaque white quartz.
Pupil: obsidian.
Caruncle: none.

[1] G. Daressy, *Statues de divinités*, I, No. 38260 (25th Dynasty); No. 38319 (25th to 26th Dynasties); No. 38422 (Ethiopian period).
[2] No. J. 34462 (22nd to 25th Dynasties).
[3] Not numbered (23rd to 25th Dynasties).
[4] No. J. 48065.
[5] No. J. 46592.

Five Anthropoid Coffins (*Late Egyptian period*).[1] Cairo Museum.

Eyelids: two pairs, blue glass; three pairs, black glass.

White: four pairs, crystalline limestone; one pair, opaque white glass.

Pupil: one pair, obsidian or black glass; two pairs, black glass; two pairs, neither obsidian nor black glass, but possibly painted.

Inlaid Eyes in Mummies (Class II)

The practice of inlaying artificial eyes in mummies did not begin until a late period. According to Elliot Smith and Warren Dawson[2] it ' was already coming into vogue in the XXth. dynasty ' and Elliot Smith gives a number of examples; thus he says of the mummy of Queen Notmit[3] (Twenty-first Dynasty), ' Artificial eyes, made of white and black stone, were inserted under the eyelids. This is the earliest instance of the use of stone eyes or of the attempt to represent the pupil in an artificial eye in a mummy, although in statues such objects had been in use more than fifteen centuries.' This writer, however, makes the same statement about Ramesses III (Twentieth Dynasty), namely[4] ' The mummy of Ramesses III is I believe the earliest in which this device has been found.' Other examples of similar inlaid eyes in mummies mentioned by this writer are those of Queen Makeri (Twenty-first Dynasty) and of five other mummies of the Twenty-first and Twenty-second Dynasties respectively.[4] I have not examined these eyes, but from the description they all appear to be of Class II.

In this connexion may be mentioned the mummy of a certain Horsiesi, priest of Amun at Thebes (the date is not given), which was unwrapped by Pettigrew. According to Clift[5] it has ' a pair of artificial eyes, apparently of enamel.' Enamel, however, was not used in ancient Egypt, and the eyes were probably similar to those described by Elliot Smith; if so, they would be Class II.

Budge states[6] that ' In the case of women of quality eyes made of obsidian and ivory were inserted in the eye-sockets.'

[1] Nos. $\frac{21}{16}|\frac{11}{5}$; $\frac{6}{16}|\frac{11}{1}$; $\frac{5}{16}|\frac{11}{9}$; $\frac{27}{16}|\frac{9}{2}$; J. 35055.

[2] G. Elliot Smith and W. R. Dawson, *Egyptian Mummies*, p. 113.

[3] G. Elliot Smith, *The Royal Mummies*, p. 96.

[4] G. Elliot Smith, *op. cit.*, pp. 87, 99, 103, 105, 108–9, 111, 114.

[5] W. R. Dawson, Pettigrew's Demonstrations upon Mummies, *Journal of Egyptian Archaeology*, xx (1934), p. 174.

[6] E. A. Wallis Budge, *A Guide to the First, Second and Third Egyptian Rooms*, 1924, p. 17.

Inlaid Eyes in Mummy Masks and Coffins (Class II)

All the mummy masks and coffins of the Graeco-Roman period in the Cairo Museum that are easily accessible, having inlaid eyes (sixty-six masks and eight coffins[1]), have been examined by me, the eyes of forty-one of the masks and of all the coffins being found to be Class II.

Eyelids: occasionally metal, copper or bronze, but usually glass; generally blue, though sometimes black, or such a dark blue that by mere inspection it is impossible to be sure of the colour.

Eyelashes: there is only one instance of eyelashes, these being in the usual form of serrated edges to a prolongation of copper eyelids.

White: usually opaque white glass, but occasionally crystalline limestone. Whether any of the eyeballs are wedge-shaped could not be determined, since they could not be taken out of the sockets for examination. In one instance, however, an eye was loose and this was examined and refixed in the socket, and in another instance an eye was broken and its construction was evident. In both cases the white was a flat piece of glass with a slightly rounded upper surface and a hole in the middle for the insertion of the pupil.

Cornea: none.

Iris: usually none, but in two instances there are irides, one pair brown and one pair grey. The brown irides consist of brown glass, in the middle of which is a small circular pupil of blue glass. The grey irides appear to be a narrow edge of white paint under the outer edge of the black pupil.

Pupil: generally opaque black glass, but possibly obsidian in one instance; in one instance brown glass and, as already stated, in one instance blue glass.

Caruncle: only occasionally present and then red paint.

These eyes have been described in detail by Edgar[2] and summarily by Petrie.[3] Edgar, summarizing his detailed description, says 'On the 1st. century masks . . . if inlaid it is made of opaque material, stone or glass,' and he adds 'So far as I have had them examined and tested, they seem to be usually, if not always, of glass.' Petrie, referring to the eyes of certain Ptolemaic mummies, writes 'they were made by bending and cutting a piece of opaque white glass to the form, inserting a disc of black glass for the iris and surrounding it with a neatly curved

[1] For the Museum numbers see A. Lucas, *Technical Studies*, VII, No. 1, July 1938, p. 18.

[2] C. C. Edgar, *op. cit.*, p. vi.

[3] W. M. F. Petrie, *Hawara, Biahmu and Arsinoë*, p. 17.

border of blue glass, always polished on the upper surface . . .' He also states that 'The gilt busts of more substantial form, about 50 A.D., required more solid work; and the eyes are then cut in white marble, tapering wedge-shaped behind and with a hole drilled in the middle to receive an iris plug of black glass, or obsidian. The finest portrait busts demanded higher work, and then the iris was of clear brown glass or stone, with a pupil of black glass inserted, giving a still more lifelike expression, heightened by the corners of the white being touched with red.'

Other Examples of the Graeco-Roman Period

Three Statuettes of Divinities.[1] Limestone. Cairo Museum.
Eyelids: in one case, none; in one case, blue glass; in the third case, a black border as part of the white glass eyeball.
White: opaque white glass.
Pupil: black glass.
Caruncle: none.

Small Wooden Bust.[2] Cairo Museum.
Eyelids: none.
White: crystalline limestone.
Pupil: obsidian or black glass.
Caruncle: none.

Four Silver-gilt Statuettes.[3] Cairo Museum.
Eyelids: two blue glass; two very dark blue, or black, glass.
White: opaque white glass.
Pupil: black glass.
Caruncle: none.

Pair of Loose Eyes.[4]
Eyelids: none.
White: thin, slightly concavo-convex, eye-shaped pieces of bone, having in the middle of the front a flattened area to which the pupil has been attached.
Pupil: missing.
Caruncle: none.

Single Loose Eye.[5] Cairo Museum.
Eyelids: blue glass.

[1] Nos. 38413, 38902, 38903.
[2] No number.
[3] Nos. J. 46380–46383; 1st century B.C.
[4] Private collection.
[5] No. J. 63031.

White: a thin, slightly curved piece of opaque white glass flattened in the middle of the convex side where the pupil is attached.

Pupil: a thin circular piece of glass, now white and much corroded, but probably black originally.

Caruncle: none.

Examples Undated

Five Anthropoid Coffins.[1] Cairo Museum.

Eyelids: three blue glass; one probably black glass; one without eyelids.

White: three crystalline limestone; two opaque white glass.

Iris: present in one instance only and consists of a grey ring round the black pupil, probably white paint under the thin edge of the translucent black glass.

Pupil: two black glass; one transparent glass with black paint under; one obsidian, or black glass; and one neither obsidian, nor black glass, but probably painted.

Caruncle: none.

Small Gilt Wooden Statuette.[2] Cairo Museum.

Eyelids: blue glass.

White: opaque white glass.

Pupil: black glass.

Caruncle: none.

Seventeen Loose Eyes.

These consist of five pairs and seven single eyes, as follows:

Three Pairs of Huge Eyes.[3] Cairo Museum.

These vary in length from about nine inches to about eighteen inches.

Eyelids: metal, copper or bronze.

Eyeball: two limestone; one largely, or wholly, modern plaster.

Pupil: one probably black glass much corroded on the surface, which is now matt; two pairs are without pupils.

Caruncle: none.

Pair of Coffin Eyes.[4] Cairo Museum.

Eyelids: copper corroded.

Eyeball: crystalline limestone.

Pupil: obsidian.

Caruncle: present in both canthi of both eyes.

[1] Nos. J. 33618; J. 41097; $\frac{17}{26}|\frac{1}{5}$; $\frac{23}{27}|\frac{1}{1}$; $\frac{21}{18}|\frac{11}{3}$.

[2] No. J. 35215.

[3] Nos. (*a*) $\frac{20}{24}|\frac{11}{18}$, $\frac{20}{24}|\frac{11}{5}$; (*b*) J. 37052 and $\frac{20}{24}|\frac{11}{18}$; (*c*) No number.

[4] No. $\frac{26}{25}|\frac{8}{3}$.

Pair of Very Small Eyes.[1]
Eyelids: none.
Eyeball: crystalline limestone.
Pupil: probably obsidian (one missing).
Caruncle: none.

Seven Single Eyes. Three Cairo Museum[2]; four private collection.
Eyelids: two blue glass; one steatite[3]; four missing.
Eyeball: four crystalline limestone; three opaque white glass.
Pupil: three probably obsidian; three black glass; one missing.
Caruncle: present in one instance only and in both canthi.

Class III

These eyes were included at first with those of Class II. The total number known to me is very small, namely, five pairs and four single ones in my private collection and one single one shown to me by the late Mr. R. H. Blanchard of Cairo. I have also parts of two others, one being an iris with pupil attached and the other only the pupil.

This type of eye is known to me only from Roman mummy masks from the Fayum province; it is anatomically better, and hence more effective, than the Class II eye, because there is always an iris.

Eyelids: copper.

Eyelashes: the usual prolongation of copper eyelids with serrated edges. Whether there were eyelashes in all cases it is impossible to say, but, although they now remain in only two instances, there is evidence that there have been others.

Eyeball: crystalline limestone, all more or less wedge-shaped, which vary in depth from back to front from 1.5 to 2.3 centimetres (approximately one half to one inch), the deeper eyeballs being true wedges tapering almost to a point behind, and the shallower ones having a flat surface at the back. In the middle of the front of the eyeball there is a deep, circular, and generally conical, hole for the insertion of the iris and pupil.

Cornea: none.

Iris: this consists of a conical glass plug having an outer diameter of from 10 to 15 millimetres (approximately 0.4 to 0.6 inch), with a circular hole in the middle for the insertion of the pupil. In one

[1] Private collection.
[2] $\frac{8}{26}|\frac{12}{18}$; J. 36218; $\frac{11}{32}|\frac{5}{1}$.
[3] The eyelids are fastened to the eyeballs by means of black resin, which is also used to fasten in the pupils.

instance, the iris is very light greenish-brown in colour; in another instance it is light green; in two instances it is partly light green and partly black and in the remaining cases it is black. It was suggested previously[1] that these irides probably were black originally and that the present lighter colours of several of them were due to decomposition and chemical change, since in most there is a definite decomposition of the glass. It is now thought, however, that the original colour was brown, or greenish-brown, and that the black is the result of decomposition. The evidence for this is twofold: first, that the one specimen that shows no decomposition is a light greenish-brown colour; and, second, that had the original colour been black, there would not have been any reason for a separate iris, since it would have been indistinguishable from the pupil, and, therefore, a large black pupil similar to that of Class II eyes would have done equally well.

Pupil: a small cone-shaped plug of black glass fitting into the hole in the iris. Between the pupil and the iris there is generally, though not always, a very thin piece of copper foil, so thin that it hardly shows at the surface.

Caruncle: none.

CLASS IV

Dr. G. A. Reisner found in the Mycerinus pyramid temple at Giza[2] four loose eyes and parts of the frame of a fifth 'probably from one wooden statue and three statuettes,' which he describes as 'Five crystal eyes set in copper.' They are all of Fourth Dynasty date.

As these eyes are now in the Museum of Fine Arts, Boston, I have not been able to examine them, but the description given by the finder is as follows:

Eyelids: copper. In one place the material is given as bronze, but this is most improbable at such an early date.

White: there is no eyeball; the whole front of the eye is one piece of transparent rock crystal, the outer surface of which is polished. In one instance the back is matt and convex, while in another instance it is flat. On the back of the rock crystal the white of the eye is shown by means of white paint.

Cornea: there is no separate cornea, though that part of the rock crystal covering the iris and pupil represents the cornea.

[1] A. Lucas, *Ancient Egypt and the East*, 1934, p. 96.
[2] G. A. Reisner, *Mycerinus*, p. 114.

Iris: painted in dark red at the back of the rock crystal.

Pupil: shallow, circular hole in the rock crystal (presumably at the back, though this is not expressly stated), filled with black material.

Caruncle: painted at the back of the rock crystal.

Part of what probably was originally a similar eye of Middle Kingdom date in the Cairo Museum[1] consists of a curved piece of transparent rock crystal of the 'almond' shape of the conventional eye, polished at both sides and with rounded edges. This has a small, circular recess at the middle of the back for the insertion of the pupil, which is missing.

What is also probably a somewhat similar eye is that of the celebrated bust of Nefertiti now in the Berlin Museum. The description of this eye (there is only one), which I owe to the kindness of Professor Alexander Scharff, is that of Professor Rathgen, who examined it, and which is as follows: *Der Grund der Augen (das Weiss im Auge) ist der Kalkstein der Buste, die Pupille ist eine schwarze Scheibe aus Wachs, die äussere Fläche des erhaltenen Auges ist aus Bergkristall.*

Some of the eyes from mummy masks of the Graeco-Roman period are of almost the same technique as that just described, though much inferior both in material and workmanship. I have examined the eyes of twenty-three of these masks in the Cairo Museum,[2] with the following results:

Eyelids: painted.

White: the white plaster of the mask, the colour possibly enhanced in some instances by means of white paint.

Cornea: none.

Iris: none.

Pupil: black paint.

Caruncle: none.

The whole front of the eye is covered with a thin, curved piece of transparent glass which sometimes is now iridescent, owing to surface decay. This glass cover often is of very irregular shape and badly fitted into the socket, but since the edges are buried in the plaster of the socket, they do not show unless the eye is damaged.

Edgar says[3] of these eyes 'But on the heads of the present class the eye is usually inlaid in a different way; a small, convex sheet of

[1] A. Lucas, *Ancient Egypt and the East*, 1934, p. 89. Museum No. J. 60261.

[2] For the Museum numbers see A. Lucas, *Technical Studies*, VII, No. 1, July 1938.

[3] C. C. Edgar, *op. cit.*, p. vi.

transparent glass or mica is laid over a plaster ground on which the iris is painted in black.' With further respect to the mica mentioned, Edgar states[1] that 'On some of the specimens which I have seen the material looked like mica, but in most cases it seems to be artificial glass, sometimes iridescent and sometimes full of small air bubbles.' I have examined carefully the eyes of all these masks and cannot find any in which the material is mica.

A statuette from the tomb of Tut-ankhamun[2] has eyes of this type with gold eyelids: the nature of the white was not determined; the pupil is black paint; there is a caruncle in both canthi of both eyes and the whole of the front of the eyes is covered with transparent, colourless glass.

Class V

This type of eye is a very poor imitation of the natural eye and consists of eyelids, eyeball and pupil only, all made in one piece. The material may be limestone, fine-grained white sandstone, faience, glass, or painted wood.

Examples

Single Eye[3] (*Nineteenth to Twentieth Dyns.*). Cairo Museum.

This was found at Kantir and consists of an eye-shaped tray with raised border, which latter represents the eyelids, the eyeball being the bottom of the tray, in the middle of which a large pupil has been painted in deep black. The material of the eye is a very-fine-grained white sandstone, which is artificially coloured slightly black on the surface.

Two Stone Statuettes[4] (*Roman period*). Cairo Museum.

The eyelids, eyeball and pupil are all one piece of glass, the eyelids being represented by a black border to the eyeball, which is opaque white; the pupil is black.

Pair of Eyes[5] (*undated*). Cairo Museum.

The eyelids, eyeball and pupil are all one piece of glass, the eyelids being blue, the eyeball opaque white and the pupil black.

[1] C. C. Edgar, *op. cit.*, p. vi.
[2] Museum, No. J. 60732.
[3] No. J. 64085.
[4] L. Borchardt, *op. cit.*, IV, Nos. 1190, 1191.
[5] No. J. 25034.

Single Eye[1] (*undated*). Cairo Museum.

The eyelids, eyeball and pupil are all one piece of faience, the eyelids and eyeball being coated with blue glaze and the pupil with black glaze, the latter being slightly corroded on the surface.

Four Single Eyes[2] (*undated*). Cairo Museum.

These eyes are all of slightly different sizes. Three consist of an eye-shaped framework, or tray, with a raised border to represent the eyelids, the bottom of the tray representing the eyeball, in the middle of which is a raised oval-shaped pupil with a convex upper surface. The whole is one piece of limestone, blackened superficially. The fourth eye consists of an eye-shaped tray with raised border without pupil, the whole being one piece of limestone blackened superficially.

Two Single Eyes[3] (*undated*). Cairo Museum.

These, which are not a pair, are from coffins and consist of painted wood. They differ both in size and in technique and are as follows:

Eyelids: painted black directly on the wood in each case.

White: in one case, painted white directly on the wood; in the other case the wood is covered with a thin coat of white plaster.

Iris: in one case, none; and in the other, painted red on the white plaster.

Pupil: painted black directly on the wood in one case and painted black on the white plaster in the other case.

Caruncle: painted red on the white plaster in one case, and painted red on white paint in the other. There is a caruncle in each canthus of each eye.

Class VI

This type of eye is only partly inlaid and is confined to bronze statuettes. The eye sockets are part of the bronze casting and in each corner of each socket is inlaid a small triangular piece of gold, or occasionally silver or electrum, leaving a circular area of bronze uncovered in the middle to represent the pupil. Thirty-one of these statuettes in the Cairo Museum[4] have been examined by me, the dates, where they are known, ranging from the late Egyptian period to Ptolemaic times. Daressy, who has described a large proportion of these statuettes, calls most of the examples of gold inlay, silver.[5]

[1] No. $\frac{2}{2}\frac{1}{6}|\frac{1}{1}\frac{2}{7}$.

[2] Nos. J. 64767–64769, one without number.

[3] Nos. $\frac{2}{2}\frac{2}{7}|\frac{9}{2}$ a, $\frac{2}{2}\frac{2}{7}|\frac{9}{2}$ b.

[4] For the Museum numbers see A. Lucas, *Technical Studies*, VII, No. 1. July 1938, p. 26.

[5] G. Daressy, *Statuettes de divinités*, I.

Not Classified

A grotesque figure in wood of unknown date in the Cairo Museum[1] has eyes consisting of translucent red material, which is called carnelian in the register, but which is either red glass, or garnet, but probably glass. A loose eye of similar material was shown to me by the late Mr. R. H. Blanchard of Cairo, who thought it was from a pottery figure of Roman date.

Non-Human Eyes

A large number of non-human eyes in the Cairo Museum have been examined by me and are as follows:

Two Leopards' Heads (Twelfth Dyn.).

These are on mirror handles, each of which has a double face with inlaid eyes. The eyelids are silver and the whole eye is covered with a thin curved plate of rock crystal, under which the pupils are painted, the white of the eye probably being plaster. In one case,[2] one eye is missing. Vernier says[3] of one head that the eyes are rock crystal, and of the other that they are of felspar and rock crystal. Bénédite says[4] of one that the cover is glass or quartz, the white (which he calls the cornea) perhaps ivory, the iris painted and the pupil (which he calls *le cristallin*) *un point gravé en creux et enduit de noir.*

Tomb of Tut-ankhamun

Lions' Heads: (*a*) on throne; (*b*) on couch; (*c*) on bow case; (*d*) *Leopards' Heads*; (*e*) *Lion-headed god*; (*f*) *Ibex.*

Eyelids: (*a*), (*c*), (*e*), not determined; (*b*) black glass; (*d*) blue glass; (*f*) metal, copper or bronze.

White: painted except in (*e*) and (*f*), which have no white.

Iris: (*a*) gold leaf; (*b*), (*c*), (*d*), (*e*) yellow paint; (*f*) brown paint.

Pupil: painted black in all cases.

Caruncle: none.

Cow's Head.

Eyelids: black glass.

White: probably white opaque glass, not crystalline limestone, as previously stated by me.[5]

[1] No. $\frac{9}{27}|\frac{8}{9}$.

[2] No. 53104.

[3] E. Vernier, *op. cit.*, Nos. 53161 and 53104.

[4] G. Bénédite, *op. cit.*, Nos. 44087 and 44088.

[5] A. Lucas, *Ancient Egypt and the East*, p. 94.

Iris: none.
Pupil: obsidian or black glass.
Carter refers to the 'inlaid eyes of lapis lazuli glass.'[1]

Anubis.
Eyelids: gold.
White: crystalline limestone.[2]
Pupil: probably obsidian.
Caruncle: present in both canthi of both eyes.
Carter states[1] that the eyes 'are inlaid with gold, calcite and obsidian.'

Cobras: (*a*) two on arms of throne; (*b*) six on back of throne; (*c*) large cobra on stand; (*d*) two serpent standards.
Iris: (*a*) probably gold leaf; (*b*) yellowish calcite; (*c*) red, painted; (*d*) brown, painted.
Pupil: (*a*), (*c*), (*d*), painted black; (*b*) probably painted, but now almost entirely disappeared.
The whole eye in (*a*), (*c*), (*d*) is covered with colourless, transparent glass; (*b*) no cover.

Birds.
Many of the birds' eyes are probably obsidian.

Horse Blinkers.
There are inlaid eyes on two of the blinkers.
Eyelids: blue glass.
White: crystalline limestone.
Pupil: probably obsidian.
Caruncle: none.

Other Non-Human Eyes

Bulls and Cows.
An excellent and detailed account of the inlaid eyes of mummies of bulls and cows from Armant has been published by Myers.[3] In these eyes the eyelids, when present, are metal, either copper or bronze, and in one case certainly bronze; the white is usually opaque white glass, but occasionally limestone, with one example of chert and one of ivory; the pupil is generally black glass, but occasionally obsidian, with two examples of red glass, one of yellow glass and one of black paint, and the caruncle, wrongly called the canthus, when present, instead of being painted as in the human eyes described, and in Tut-ankhamun's cow's eyes, is inlaid in red glass.

[1] Howard Carter, *op. cit.*, III, p. 41.
[2] Tested since last described.
[3] Sir Robert Mond and O. H. Myers, *The Bucheum*, I, pp. 65–7.

Head of Anubis from Armant[1] (*Fourth Century* B.C. *to Fourth Century* A.D.). Cairo Museum.

Eyelids: blue glass.
White: opaque white glass.
Pupil: black glass.
Caruncle: none.

Hawk from Hierakonpolis (*Sixth Dyn.*). Cairo Museum.

The eyes 'are formed by a single rod of obsidian polished in a spherical curve at each end . . .'[2] There are no eyelids. I had the good fortune to be able to examine this rod of obsidian on one occasion when it was removed temporarily from the head. Wainwright refers to the use of obsidian for the eyes of a very large bird statue of the same place and date, which is now in the Museum of University College, London.[3]

Two Hawks in a Pectoral (*Middle Kingdom*). Cairo Museum.

These have amethyst eyes, and two hawks' heads of the same date have garnet eyes, both of which are described by Vernier.[4] The finder of the hawks' heads, de Morgan, says[5] that the eyes are of such a good colour that they must be ruby and not carnelian. The eyes of the hawks in a pectoral of the same date in New York are also of garnet.[6]

Cobras (*Middle Kingdom*). Cairo Museum.

Three uraei belonging to jewellery have garnet eyes. These are:

No. 52641. Uraeus in crown. Vernier calls the eyes obsidian,[7] although the finder, Brunton, states that they are garnet.[8]

No. 52702. Uraeus. One eye is missing. Vernier calls the other eye obsidian.[7]

No. 52915. Head of Uraeus. Vernier correctly describes the eyes as garnet.[7]

Fish.

Miss Caton-Thompson[9] found an amuletic fish of Twelfth Dynasty date, which had eyes of lapis lazuli.

Loose Eyes. Cairo Museum.

Two non-human eyes of Middle Kingdom date described by Vernier[10] as those of a falcon, but which Brunton tells me are from a goose, or swan,[11]

[1] No. J. 55620.
[2] W. M. F. Petrie and J. E. Quibell, *Hierakonpolis*, I, p. 11.
[3] G. A. Wainwright, Obsidian in Ancient Egypt, *Ancient Egypt*, 1927, p. 88.
[4] E. Vernier, *op. cit.*, Nos. 52712, 52861, 52862.
[5] J. de Morgan, *Fouilles à Dahchour*, 1894–95, p. 58.
[6] G. Brunton, *Lahun*, p. 28. [7] E. Vernier, *op. cit.*
[8] G. Brunton, *op. cit.*, p. 27.
[9] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, p. 138.
[10] E. Vernier, *op. cit.*, Nos. 52951–52952. [11] G. Brunton, *Lahun*, I, p. 38.

are small, almost round, and so corroded that, until they have been cleaned, their nature cannot be determined with certainty. The eyelids are copper and the whole eye is covered with what is probably rock crystal.

Montet found at Tanis[1] a pair of animal eyes of late date, of which the eyelids are metal, either copper or bronze, the front of the eye being an almond-shaped concavo-convex piece of rock crystal, on the under side of which is an inverted, pear-shaped, vertical pupil painted in black, behind which is thin gold leaf for the iris.

Two Pairs of Eyes[2] (*undated*).

From their shape, these are almost certainly from mummies of bulls or cows.

Eyelids: blue glass, but present only in one eye.

Eyeball: missing in one pair of eyes and partly missing in the other pair. The nature of the material cannot be determined without chemical analysis, but probably both the remaining parts are corroded glass.[3]

Pupil: probably obsidian.

Caruncle: none.

It seems highly probable that a mistake has been made in pairing these eyes, since one pupil of each pair is thick and deeply grooved all round the edges, except the top, so that it might be keyed into the eyeball or white; one pupil is much thinner and has no groove, and one pupil has a tenon at the back for fixing it into a socket.

[1] No. J. 63151.

[2] Nos. $\frac{22}{26}|\frac{12}{12}$, $\frac{22}{26}|\frac{12}{15}$, $\frac{22}{26}|\frac{12}{14}$, $\frac{22}{26}|\frac{12}{15}$.

[3] One of the eyeballs was previously reported by me (A. Lucas, *Ancient Egypt and the East*, December 1934, pp. 96–7) as crystalline limestone because it effervesced considerably with acid, and the other eyeball was reported as probably magnesite, or magnesian limestone, of which it has all the appearance. It is covered with white powder and does not effervesce. See Sir R. Mond and O. H. Myers, *The Bucheum*, I, pp. 70–1.

CHAPTER VIII

FIBRES: WOVEN FABRICS AND DYEING

Under the head of fibres it is proposed to deal with, not only the fibres employed for making Woven Fabrics, but also, though very briefly, those used for Basketry, Brushes, Cordage, Matting and Paper, which may conveniently be done in alphabetical order.[1]

Basketry

The making of baskets, or plaiting, was one of the first arts practised by primitive man, being earlier than weaving, of which, as pointed out by Lucretius, it is but the first step, and manifestly it is the simpler of the two, since in basketry no other preparation of the fibre is necessary beyond the selection and cutting into lengths, with sometimes, as in the case of palm leaves, the splitting into suitable widths, whereas before weaving is possible there must always be some preliminary treatment, thus all fibres must be spun before they can be woven and certain stems (i.e. flax), which are composed of bundles of fibres enclosed in woody tissue, must not only be separated into their component parts, but these must be cleaned from adherent material before they can be employed. Also, baskets are made without the use of any kind of machinery, whereas the appliances of distaff, whorl and spindle are required for spinning and a machine (the loom) for weaving, before woven fabrics can be produced.

In Egypt, the making of baskets dates back to neolithic times,[2] which probably came to an end about 7,000 years ago.

The subject of basket making in ancient Egypt is one that has been very little studied, either with regard to the materials or to the

[1] The use of halfa grasses, both *Demostachya* and *Imperata*, and the use of reed, both *Arundo and Phragmites*, in ancient Egypt for mat making, rope making and other purposes is discussed and a very large number of references are given in *Flora of Egypt*, by V. and G. Täckholm and M. Drar, Vol. 1, Cairo, 1940, pp. 180–5, 485–6.

[2] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 43, 44, 46, 89.

technique of the methods employed, and although numerous references can be found to materials stated to have been used, these statements are of such different values, and some are of such doubtful worth, that any list of them would be misleading.

The principal materials employed were the leaves of the date palm both for coil and wrapping (the whole leaf being used for coarse work, but being split into narrow strips for finer work), with sometimes the split mid-rib of the branches of the date palm for foundations.[1] In the south, the leaves of the dom palm were often substituted for those of the date palm. The use of both date palm leaf and dom palm leaf by the Egyptians for plaiting is mentioned by Theophrastus.[2] These materials are still employed for basketry at the present day.[3]

Less frequent materials were grasses and other plant stems. Grass is recorded as having been used for basketry of neolithic age[4] and at various periods since, among which specimens of Badarian,[5] Eleventh Dynasty[6] and of Christian[7] dates respectively may be mentioned, but unfortunately the particular kind of grass has not always been identified. Ropes and mats, however, found with the Christian baskets were made of halfa grass (a strong, tough, wild grass that grows abundantly in north Africa, including Egypt) and possibly, therefore, the baskets too may have been made of this material. Four baskets and a tray of Eighteenth Dynasty date from Thebes were made of halfa grass, the 'bottoms, inner rims and other parts which were required to stand special wear or strain are whipped with palm-leaf strip.'[8] Newberry states[9] that 'Two species of grass were used in the manufacture of basket-work,' but the species are not named. Sometimes the coil of a basket is of grass and the wrapping of split palm leaf.

But grass was not the only plant stem employed, the use of others being known from neolithic,[4] Badarian[5] and protodynastic

[1] W. S. Blackman, *The Fellahin of Upper Egypt*, p. 304.
[2] *Enquiry into Plants*, IV: 2, 7.
[3] W. S. Blackman, *op. cit.*, pp. 155–61.
[4] G. Caton-Thompson, *Explorations in the Northern Fayum*, in *Antiquity*, I (1927), p. 335.
[5] G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 62–3.
[6] H. E. Winlock, *Bull. Met. Mus. of Art, New York, Egyptian Exped., 1925–1927*, p. 8; fig. 7.
[7] H. E. Winlock and W. E. Crum, *op. cit.*, p. 74.
[8] A. Lansing and W. C. Hayes, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1935–1936*, p. 26; W. C. Hayes, *op. cit.*, *1934–35*, p. 27.
[9] P. E. Newberry, *On the Vegetable Remains*, in *Hawara, Biahmu and Arsinoe*, W. M. F. Petrie, p. 52.

times[1] respectively. At the two earlier dates the stems were those of a dicotyledonous plant, the Badarian specimen being possibly a species of flax. The later specimens were several vase covers of predynastic or protodynastic date and two basketry coffins of the latter period, the material of which has been identified by Keimer as the stems of *Ceruana pratensis* Forsk, a small plant well known in Egypt.

In my opinion, it is very doubtful whether papyrus, sometimes stated to have been used, was ever employed for basket making in ancient Egypt though it was extensively utilized for other purposes. Thus papyrus, often associated with reeds, was used for making receptacles, which are better described as boxes rather than baskets, since basketry, as the term is here used, means a simple kind of weaving necessitating the plaiting or interlacing of the fibres, whereas these objects are not plaited. Petrie says[2] that 'Flat papyrus slices of the outer brown skin were greatly used for making boxes for food, framed on lengths of reed lashed together.' He records the finding of a papyrus box of predynastic date,[3] 'papyrus or reed boxes'[4] and 'four boxes of papyrus stems bound with palm rope,'[4] though an illustration of what is probably one of the 'boxes' just mentioned is called a 'papyrus basket.'[4] Quibell, recording an object of this nature from the tomb of Yuya and Thuyu, calls it a basket[5]: it consists of a large oblong receptacle for wigs in the form of a dwelling house and is described as being made of papyrus stems, papyrus pith and reeds. A papyrus box found in the tomb of Tut-ankhamun, described by Carter as 'a papyrus basket belonging to the King's writing outfit,'[6] so far as can be seen, appears to be made of thin slices of papyrus pith on a framework of reeds: it is lined with linen and is decorated on the top and front with narrow strips of a glossy vegetable material, probably straw, and two small gilt and painted pictures. Another box from the same tomb, which is divided into six compartments, is made of a framework and panels of reeds lined with slices of papyrus pith.

Reeds, which are special kinds of water-loving grasses, are generally firm-stemmed and, therefore, although admirably adapted for the framework of boxes, they are not suitable for basketry, since they do

[1] L. Keimer, *Ceruana pratensis* Forsk *dans l'Égypte ancienne et moderne*, in *Annales du Service*, xxxii (1932), pp. 30–7.
[2] W. M. F. Petrie, *Social Life in Ancient Egypt*, p. 143.
[3] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 26.
[4] W. M. F. Petrie, *Deshaseh*, pp. 34–5; Pl. XXXIV.
[5] J. E. Quibell, *The Tomb of Yuaa and Thuiu*, pp. 57–8; Pl. XLVIII.
[6] Howard Carter, *op. cit.*, iii, p. 215; Pl. LXVI.

not possess the required pliability, though several examples of reed baskets are known from the Badarian period[1]: they were sometimes used for making coffins[2, 3, 4, 5] and a particular kind of reed, *Phragmites communis*, was employed for making arrows and at a late date for pens. An arrow from the First Dynasty tomb of Hemaka at Saqqara has been identified as *P. communis*, var. *stenophylla*, and others from the Eighteenth Dynasty tomb of Tut-ankhamun as *P. communis*, var. *isiaca*.[6]

Both Miss Blackman[7] and Wainwright[8] have described a few ancient baskets, which they compare in regard to material and technique with modern baskets and state that they are almost identical.

The ancient baskets were often decorated, thus Wainwright says[9] that '. . . many XVIIIth dynasty baskets show regular patterns carried out in colours,' and again that 'small or finely made ones . . . are quite commonly decorated in colour, while larger ones . . . often have seams of ornamental stitching running up their sides.' Carter points out that some of the baskets from the tomb of Tut-ankhamun have patterns formed by interweaving dyed fibres with undyed fibres.[10] Petrie describes certain baskets of Twelfth Dynasty date as having woven patterns on the sides[11]; one from the Eighteenth Dynasty as being red and black[12] and one of the Roman period as red and white.[12] Four baskets and a tray decorated with designs in red and black of Eighteenth Dynasty date were found at Thebes,[13] and a coloured grass basket of the Eleventh Dynasty.[14]

Basketry work was also employed for sieves, which 'are well known

[1] G. Brunton, *Mostagedda*, p. 63.
[2] G. Brunton, *Qau and Badari*, I, pp. 13, 22, 31, 32, 47.
[3] W. M. F. Petrie, *Deshaseh*, p. 34.
[4] A. Rowe, *The Museum Journal*, Philadelphia, XXII (1931), p. 27.
[5] R. Macramallah, *Un cimetière archaïque de la classe moyenne du peuple à Saqqarah*, 1940, p. 3.
[6] By Mr. E. Greiss, botanist, Cairo University.
[7] W. S. Blackman, *op. cit.*, p. 304.
[8] G. A. Wainwright, (*a*) *Basketry, Cordage, etc., from the Fayum*, in *Annales du Service*, XXIV (1924), pp. 108–11; (*b*) *Ancient Survivals in Modern Africa*, in *Bull. Soc. sult. de géog.*, Cairo, IX (1919), pp. 177–9.
[9] G. A. Wainwright, *op. cit.* (*a*).
[10] Howard Carter, *op. cit.*, p. 149.
[11] W. M. F. Petrie, *Illahun, Kahun and Gurob*, p. 21.
[12] W. M. F. Petrie, *Objects of Daily Use*, pp. 48–9.
[13] A. Lansing and W. C. Hayes, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1935–1936*, p. 26.
[14] H. E. Winlock, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1925–1927*, p. 8; fig. 7.

from dynastic times.'[1] A specimen of Eighteenth Dynasty date had a 'mesh with a web of palm fibre crossed by warp of palm leaf,' the edging being of palm fibre bound with palm leaf.[2] Petrie found 'part of a strong sieve of rush'[3] of the Twentieth Dynasty, and an example found by Winlock from a Christian Monastery at Thebes 'had a rim made of two cords of grass wrapped around and bound together with palm leaf and a mesh made of small reeds laced together with grass and reinforced at the back with two palm sticks. . . .'[4]

Brushes

Brushes were in common use in ancient Egypt and have often been found: they were all made of vegetable fibre, though not always of the same sort of fibre, and were essentially of three kinds, namely, (*a*) bundles of coarse fibre or twigs bound together at the top with thin rope, string or palm leaf, so as to form a handle, separate wooden handles not being used; (*b*) bundles of finer fibre, though of different degrees of fineness, doubled into half their length and lashed together at the doubled end, and (*c*) pieces of fibrous wood bruised at one end until the fibres separated and formed bristles.

As examples of the first kind may be mentioned the fan-shaped brushes of split reeds used both for sweeping the floor and for fanning the charcoal used for cooking, referred to and illustrated by Petrie[5, 6]; the brush made of the fruit-stalks of dates found by Quibell[7] and the brushes formed of the twigs of *Ceruana pratensis* mentioned by Keimer.[8] Muschler, in his description of this plant, says,[9] 'Generally used for making little brooms, found . . . in old Egyptian tombs,' and it is still largely used for brush making in Egypt at the present day.[8]

Examples of the second kind are the five brushes of palm fibre of Roman date illustrated by Petrie[10] and those from the Monastery of Epiphanius described by Winlock,[11] some of which were made of halfa

[1] H. E. Winlock and W. E. Crum, *The Monastery of Epiphanius at Thebes*, p. 63.
[2] T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 74.
[3] W. M. F. Petrie, *Kahun, Gurob and Hawara*, p. 32.
[4] H. E. Winlock and W. E. Crum, *op. cit.*, p. 63.
[5] W. M. F. Petrie, *Social Life in Ancient Egypt*, p. 143.
[6] W. M. F. Petrie, *Objects of Daily Use*, p. 49; Pl. XLII (178).
[7] J. E. Quibell, *The Monastery of Apa Jeremias*, p. 17.
[8] L. Keimer, *op. cit.*, pp. 32–3.
[9] R. Muschler, *A Manual Flora of Egypt*, II, p. 969.
[10] W. M. F. Petrie, (*a*) *Hawara, Biahmu and Arsinoe*, p. 11; Pl. XIII (24, 25); (*b*) *Objects of Daily Use*, p. 49; Pl. XLII (179–84).
[11] H. E. Winlock and W. E. Crum, *op. cit.*, p. 75.

grass and some of split palm leaf, the first-named material being used for the smaller brushes and the second for the larger ones. Small stumpy brushes of this sort were employed for painting and one such was found by de Garis Davies as part of a tomb painter's outfit,[1] two by Peet and Woolley[2] and two others by Pendlebury,[3] several being still clogged with the ancient paint. These paint brushes resemble very much in general appearance a certain kind of modern shaving brush.

The wooden brushes of the third kind described were used exclusively for painting, and ten specimens were among the tomb painter's outfit mentioned.[1] These, as already explained, consist of pieces of fibrous wood of different thicknesses, probably all portions of the mid-rib of the branches of the date palm, which have been bruised at one end until the fibres have separated and formed coarse bristles, and they still have on them the ancient paint.

CORDAGE

Although no detailed study of the ropes and twines of ancient Egypt has been made, a certain number of facts relating to them are known, which may now be considered.

Rope making consists in twisting separate fine fibres into a cord, as in spinning, and then twisting a number of cords round one another. Rope was known in Egypt from the Badarian period, specimens from which were of reed.[4] From the predynastic period one specimen was of flax,[5] another of halfa fibre,[6] and a third of grass.[7] From the First Dynasty both flax[8] and grass[8] were used. From the Old Kingdom a two-strand rope of camel-hair is known.[9] Rope of flax fibre has also been found from the Twelfth Dynasty.[10] A rope of Sixth Dynasty date was composed of the fibres of a monocotyledonous plant, possibly halfa grass,[11] which was also being used, as well as date palm fibre, as late as the sixth or seventh century A.D.[12] It was the latter, however,

[1] N. de G. Davies, *Five Theban Tombs*, pp. 5–6; Pl. XVII.
[2] T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 76.
[3] J. D. S. Pendlebury, in *The Illustrated London News*, 19th March, 1933.
[4] G. Brunton, *Mostagedda*, p. 63.
[5] G. Brunton and G. Caton-Thompson, *op. cit.*, p. 67.
[6] O. Menghin and M. Amer, *The Excavations of the Egyptian University in the Neolithic Site at Maadi*, 1936, p. 49.
[7] E. R. Ayrton and W. L. S. Loat, *Pre-dynastic Cemetery at El Mahasna*, p. 17.
[8] W. B. Emery, *The Tomb of Hemaka*, 1938, pp. 43–4.
[9] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 88, 119, 123.
[10] W. M. F. Petrie, *Kahun, Gurob and Hawara*, pp. 28, 35.
[11] G. Brunton, *Qau and Badari*, I, p. 71.
[12] H. E. Winlock and W. E. Crum, *op. cit.*, p. 72.

(palm fibre) that was generally employed for rope making in ancient Egypt and it is still used to-day for the same purpose: it consists of the fibres from the naturally-reticulated fabric-like material which at first envelops the leaf and is found at the crown of the trunk of the date palm, surrounding the base of the branches. In an Egyptian papyrus document of unknown, but late, date 200 bundles of palm fibre for making ropes are mentioned.[1]

Theophrastus[2] and Pliny[3] both state that the Egyptians made ropes of papyrus, and in two rope making scenes depicted on tomb walls, one of the Fifth Dynasty[4] and the other probably of the Eighteenth Dynasty,[5] the material being employed is apparently papyrus, and Petrie refers to 'papyrus cord.'[6] In May 1942 seven very thick ropes were found buried in debris in one of the Tura caves, which are old stone quarries. These ropes were of papyrus[7] and consisted of three strands, each of which had about forty yarns and each yarn about seven fibres. The circumference was about eight inches and the diameter about two and a half inches. They are not modern, but the date is unknown. In October 1944 in another of the Tura caves a further rope of papyrus was found, which was about half the thickness of the previous one, with two strands, eight yarns per strand and three fibres per yarn.

A number of specimens of string of Eighteenth Dynasty date examined by me were all made of flax fibre.

MATTING

The making of mats has always been, as it still is, one of the important minor industries of Egypt, and mats have been found in graves from the Tasian, Badarian and predynastic periods onwards, the body frequently resting on a mat, or being covered with, or wrapped in, a mat. Mat-making is illustrated in a Twelfth Dynasty tomb at Beni Hasan.[8]

The materials principally used for the ancient mats are generally stated to have been either reeds or rushes, but these terms are often

[1] C. C. Edgar, *Zenon Papyri*, III, No. 59438.
[2] *Op. cit.*, IV: 8, 4. [3] XIII: 22.
[4] N. de G. Davies, *The Mastaba of Ptahhetep and Akhethetep*, I, Pl.. XXV.
[5] E. Mackay, *Note on a New Tomb (No. 260) at Drah Abu'l Naga, Thebes*, in *Journal of Egyptian Archaeology*, III (1916), pp. 125–6; Pl. XV.
[6] W. M. F. Petrie, *Deshasheh*, p. 33.
[7] Kindly identified by Mr. E. Greiss of the Cairo University.
[8] P. E. Newberry, *Beni Hasan*, II, Pl. XIII.

employed loosely and incorrectly and the subject of ancient Egyptian mat-making needs further work.

The Tasian matting found was made of reeds.[1] Some of the Badarian[2] and predynastic[2, 3] matting was made of reeds, some of rushes and some of grass. Certain First Dynasty mats were made of halfa grass and others of reeds (*Phragmites communis*)[4]: matting from the First Dynasty examined by me was probably grass bound with flax string[5]; some from the Fifth Dynasty at Abusir was composed of palm-ribs and palm fibre[6] and matting of Sixth Dynasty date from the Gau-Badari district of Upper Egypt was of rushes.[7] Petrie states that very thin grass was used for mats in the Hyksos period[8]: a large mat from El Amarna was of palm fibre tied with hemp cords[9] and another Eighteenth Dynasty mat was of papyrus.[10] Petrie also records mats of papyrus of predynastic date.[11] Winlock mentions grass mats of the Nineteenth Dynasty, the Twenty-sixth Dynasty and the sixth or seventh century A.D.,[12] respectively, which latter ' were all made of halfa grass bundles on 5 mm. cords of the same grass usually, but sometimes of palm fibre.' Wainwright states[13] that a mat of late New Kingdom date (Twenty-third to Twenty-fifth Dynasties) was made of soft rush. Winlock describes and illustrates[12] ' two fundamental types of weaving in the ancient mats from Egypt,' and Mrs. Crowfoot describes and compares the ancient and modern methods of mat making.[14]

Papyrus

The papyrus plant (*Cyperus papyrus*), a plant belonging to the sedge family (which at one time grew abundantly in the marshy districts of

[1] G. Brunton, *Mostagedda*, pp. 6–7, 33.
[2] G. Brunton and G. Caton-Thompson, *op. cit.*, p. 67: G. Brunton, *Mostagedda*, pp. 36, 62, 93.
[3] R. MacIver and A. C. Mace, *El Amrah and Abydos*, p. 31; Pl. XI (5, 6).
[4] R. Macramallah, *Un cimetière archaïque . . . à Saqqarah*, 1940, pp. 3, 40–2, 47–50.
[5] W. B. Emery, *The Tomb of Hemaka*, p. 43.
[6] H. Schaefer, *Priestergräber vom Totentempel des Ne-User-Rê*, p. 114.
[7] G. Brunton, *Qau and Badari*, I, p. 71.
[8] W. M. F. Petrie, *Social Life in Ancient Egypt*, p. 143.
[9] T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 81.
[10] J. E. Quibell, *The Tomb of Yuaa and Thuiu*, p. 65.
[11] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 23, 25.
[12] H. E. Winlock and W. E. Crum, *op. cit.*, pp. 72–4.
[13] G. A. Wainwright, (*a*) in *Heliopolis, Kafr Ammar and Shurafa*, W. M. F. Petrie and Others, p. 37; (*b*) *Bull. Soc. sult. de géog.*, IX, Cairo, p. 179.
[14] G. M. Crowfoot, *The Mat Weaver from the Tomb of Khety*, in *Ancient Egypt*, 1933, pp. 93–9.

Lower Egypt, where, however, it is no longer found, though it still flourishes in the Sudan), was employed by the Egyptians for many purposes, some of which have been enumerated by Herodotus,[1] Theophrastus[2] and Pliny[3] and a few of which have already been described, but its principal value was for making sheets of material for writing upon, which was the forerunner of modern paper, to which it gave its name.

Specimens of papyrus from the Sudan measured by me varied from seven feet to ten feet in length, excluding the flowering top and the root, and the maximum diameter was nearly an inch and a half (1.4 inch).[4] The stem is triangular in section and consists of two parts only, a thin tough outer rind and an inner cellular pith, and it was this latter that was employed as a writing material. The method of making sheets suitable for writing upon from this very unpromising-looking material is described by Pliny,[5] according to whom the stem of the plant was sliced into thin strips, which were placed side by side upon a table and across them at right angles another series of similar strips; they were then moistened with Nile water, pressed and dried in the sun, Pliny adding that Nile water 'when in a muddy state has the peculiar qualities of glue.' This account is both obscure and wrong. Thus there is no mention of whether the outer rind of the papyrus was removed or not before the material was sliced, though that it was removed is possibly to be inferred from a subsequent statement that the rind was 'solely used for making ropes.' Also, although the Nile water during flood is muddy, it does not contain anything that could possibly act as an adhesive. A later allusion to paste 'made of the finest flour of wheat mixed with boiling water' is far from clear, but probably refers to the fastening of a number of sheets of papyrus together to make one long sheet.[6]

Bruce[7] 'made several pieces of this paper, both in Abyssinia and Egypt,' of which he says that 'some were excellent,' though this is qualified by the further statement that 'even the best of it was always thick and heavy, drying very soon, then turning firm and rigid and never white.' Bruce is as unsatisfactory as Pliny on the point of whether

[1] II: 37, 92, 96; VII: 25. [2] IV: 8, 3, 4.
[3] XIII: 21–6; XXIV: 51.
[4] Kindly supplied by Mr. G. W. Grabham, Sudan Government Geologist.
[5] XIII: 21–6; XXIV: 51.
[6] Pliny's account is described by D. de la Molle, in *Mémoire sur le papyrus et la fabrication du papier chez les anciens*, 1850.
[7] J. Bruce, *Travels to Discover the Sources of the Nile*, 1805, VII, pp. 117–31.

the rind was removed or not before the papyrus was sliced, though apparently not, since he says, 'There seemed to be an advantage in putting the inside of the pellicle in the situation in which it was before being divided, that is, the interior parts face to face, one long-ways and one cross-ways, after which a thin board of the cover of a book was laid first over it and a heap of stones piled upon it.' This was done, as expressly stated, 'while moist,' after which 'they were suffered to dry in the sun.' Bruce adds that it appeared to him 'that the sugar or sweetness, with which the whole juice of this plant is impregnated, is the matter that causes the adhesion of these strips together.'

I tried to make papyrus paper by peeling off the rind, slicing the pith and strongly pressing the slices together, but was unsuccessful, because, as I now know, the papyrus was not fresh, but consisted of plants that had been sent to Cairo from the Sudan, the pith of which had become dry.

Battiscombe Gunn, who succeeded in making excellent papyrus paper,[1] from plants grown in his garden at Ma'adi, according to a method worked out by Miss E. Perkins, was good enough to demonstrate the method employed, as a result of which I have been able to produce similar material. The method is to cut a number of sections of the fresh green papyrus stems into lengths that can easily be manipulated; strip off the outer rind; separate the inner pith into thick slices (not necessarily all of exactly the same thickness) by making a cut with a knife at one end and then pulling off the slices; place an absorbent cloth on a table and on this arrange a number of slices of the pith parallel to and slightly overlapping one another and across them at right angles a further lot, also slightly overlapping; cover with a thin absorbent cloth and beat the whole for an hour or two with a rounded stone of a size that can be held comfortably in one hand or with a wooden mallet and finally place the material in a small press for several hours or over night. The slices become welded together, adhering firmly to one another and forming one homogeneous sheet of thin paper suitable for writing upon,[2] the surface of which may be improved by burnishing. The colour of the paper produced, although almost white, was unfortunately marred by being spotted with numerous small light-brown coloured specks, which doubtless could be avoided if special precautions were taken. Any holes or thin places are easily patched before the sheet is pressed and dried by putting a

[1] Now exhibited in the Cairo Museum.

[2] Without the addition of any extraneous adhesive.

small piece of fresh pith on the defective place and beating until it becomes merged into the rest.

The date when papyrus paper was first made is not known, but in the Cairo Museum there are small papyrus documents from both the Fifth[1] and the Sixth Dynasties,[2] and a recent find of ten documents of Sixth Dynasty date from Gebelein is reported.[3] Earlier still, however, is an unused roll from the First Dynasty.[4]

Woven Fabrics

The woven fabrics, like most other objects that have survived from ancient Egypt, are those that have been found in tombs, which are largely confined to wrappings for the dead. Occasionally, however, a garment worn during life, such as a shirt, is discovered on a body, or fabrics other than those on the body have been placed in the tomb.

Spinning and weaving were among the oldest of the arts practised in Egypt and woven fabrics from as early as the neolithic period[5] have been found. Flax cultivation, treatment of the flax fibre by beating, spinning and weaving or some of these operations are represented on the walls of several tombs of the Twelfth Dynasty at Beni Hasan[6, 7] and El Barsheh[8] respectively and also in Eighteenth Dynasty tombs at Thebes[9] and a model of Eleventh Dynasty date showing women engaged in spinning and weaving was found by Winlock at Thebes[10, 11] and is now in the Cairo Museum.

Various aspects of spinning and weaving in ancient Egypt have been studied and described,[12, 13, 14, 15] one article (Mrs. Crowfoot's)

[1] Nos. C.G. 58063, 58064.
[2] Nos. J. 49623, C.G. 58043.
[3] *Chronique d'Égypte*, 1936, pp. 57–8.
[4] W. B. Emery, *The Tomb of Hemaka*, 1938, p. 14.
[5] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 46, 49, 88, 90.
[6] P. E. Newberry, *Beni Hasan*, I, Pls. XI, XXIX; II, Pls. IV, XIII.
[7] F. Ll. Griffith, *Beni Hasan*, IV, Pl. XV.
[8] P. E. Newberry, *El Bersheh*, I, Pl. XXVI.
[9] N. de G. Davies, (*a*) *Five Theban Tombs*, Pl. XXXVII; (*b*) *The Tomb of Nefer-Hotep at Thebes*, Pl. LX.
[10] H. E. Winlock, *The Egyptian Expedition, 1918–1920*, in *Bull. Met. Mus. of Art, New York*, II (1920), p. 22.
[11] H. Ling Roth and G. M. Crowfoot, *Models of Egyptian Looms*, in *Ancient Egypt*, 1921, pp. 97–101.
[12] H. E. Winlock, *Heddle-Jacks of Looms*, in *Ancient Egypt*, 1922, pp. 71–4.
[13] A. C. Mace, *Loom Weights in Egypt*, in *Ancient Egypt*, 1922, pp. 75–6.
[14] G. Crowfoot, (*a*) *Hand Spinning in Modern Egypt*, in *Ancient Egypt*, 1928, pp. 110–17; (*b*) *Methods of Hand Spinning in Egypt and the Sudan*, in *Bankfield Museum Notes*, Second Series, 1931.
[15] W. M. F. Petrie, *Kahun, Gurob and Hawara*, pp. 27–8.

dealing with the similarities between the ancient and modern methods. The yarn was spun by hand (chiefly by women) on a small spindle that dangled by the thread that was being twisted. The loom was a hand one and was horizontal until the Hyksos invasion, when a vertical loom was introduced.

Distaffs,[1] spindles, spindle whorls and loom weights have often been found.

The principal kind of woven fabrics found in Egyptian tombs until a late date are of linen, though fabrics of grass and of reed fibre have also been discovered. Wool, although probably always used for clothing to at least some extent and certainly at a late date, was accounted ceremonially unclean and so, as Herodotus, referring to the Egyptians, said[2] ' nothing of wool is brought into temples, or buried with them; that is forbidden.' At a very late period the knowledge, first of cotton and then of silk, reached Egypt. All of these materials may now separately be described in order of importance.

Linen

Flax (originally *Linum humile*, but now *Linum usitatissimum*) has been grown in Egypt from very early times, since linen fabrics have been found of neolithic,[3] Badarian,[4] predynastic[5,6] and First Dynasty[7] dates respectively, and there is still a considerable flax cultivation in the country. The commercial side of flax growing in Egypt is referred to by Pliny, who states[8] that ' by its aid . . . she imports the merchandise of Arabia and India ' and that it was from Egyptian flax that ' the greatest profits are derived.'

The old Egyptian linen varies considerably in texture, from the finest gauze to a canvas-like coarseness. The nature and quality of the weaving have been investigated by various experts, notably, J. Thomson[9];

[1] Wilkinson (J. G. Wilkinson, *The Ancient Egyptians*, 1890, II, 87–8) confuses the distaff with the spindle.

[2] II: 81.

[3] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, p. 46.

[4] G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 64–7.

[5] G. Brunton, *Qau and Badari*, I, pp. 70–1.

[6] W. M. F. Petrie, *Prehistoric Egypt*, p. 47.

[7] W. B. Emery, *The Tomb of Hemaka*, p. 43.

[8] XIX: 2.

[9] *Lond. and Edin. Phil. Mag.* 5, 1834. Quoted at great length by Wilkinson (*The Ancient Egyptians*, II (1890), pp. 75–9).

W. W. Midgley[1]; T. Midgley[2]; T. W. Fox[3]; W. G. Thomson[4]; A. F. Kendrick[5]; A. V. Henneberg[6]; H. Ling Roth[7]; and Mrs. G. M. Crowfoot.[8] T. Midgley says, 'The structure of textile fabrics of the earlier dynastic period in Egypt is now fairly well understood, and the character of the loom and its accessories equally well known. . . . From the tomb paintings . . . we have learnt how the flax stem was treated to obtain the bast fibres, how these were cleansed, heckled, roved, spun and warped. Finally, we have in these pictures the breast and warp beams shown pegged to the ground, lease rods and heddles inserted, and the weaving of cloth from these carefully prepared yarns. No reed was used, so that . . . there is a great irregularity in the spacing of the warp threads as compared with modern fabrics; . . . Apart from this, it is singular how little within the range of plain weaving which is known to-day was not practised by the weavers of the Old Kingdom. . . . Thus at the very dawn of the historic period in Egypt we find the craft of the spinner and the weaver very highly developed in technique; manifestly the early stages of the evolution of the loom must be sought far back in the predynastic era.'

A few small fragments of coloured tapestry-woven linen fabric were found in the tomb of Tuthmosis IV[9] and a number of coloured tapestry-woven linen objects in the tomb of Tut-ankhamun, and also cases of applied needlework.[10, 11, 12]

Winlock found pleated linen of Eleventh Dynasty date[13] and in the Cairo Museum there are three specimens of pleated linen of the

[1] (*a*) In *Historical Studies*, Brit. School of Arch. in Egypt, pp. 37–9; (*b*) In *Heliopolis, Kafr Ammar and Shurafa*, W. M. F. Petrie and E. Mackay, pp. 48–51.

[2] (*a*) In *The Badarian Civilization*, G. Brunton and G. Caton-Thompson, pp. 64–7; (*b*) In *Qau and Badari I*, G. Brunton, pp. 70–1.

[3] In *The Tomb of Two Brothers*, M. A. Murray, pp. 65–9.

[4] In *The Tomb of Thoutmôsis IV*, H. Carter and P. E. Newberry, pp. 143–4.

[5] *Catalogue of Textiles from Burying-Grounds in Egypt*, I, II, III.

[6] A. V. Henneberg, Die altägyptischen Gewebe des Ethnographischen Museums im Trocadero, *Bull. du Musée d'ethnographie du Trocadéro*, July 1932, pp. 3–17.

[7] H. Ling Roth, *Studies in Primitive Looms*, 1934.

[8] Mrs. G. M. Crowfoot, (*a*) *Methods of Hand Spinning in Egypt and the Sudan*, 1931; (*b*) The Tunic of Tutankhamun, *Journal of Egyptian Archaeology*, 27 (1941), pp. 113–30.

[9] H. Carter and P. E. Newberry, *The Tomb of Thoutmôsis IV*, pp. 143–4.

[10] H. Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I, pp. 171, 172.

[11] H. Carter, *The Tomb of Tut-ankh-Amen*, III, pp. 124–6.

[12] R. Pfister, Les textiles du tombeau de Toutankhamon, *Revue des arts asiatiques*, XI (1937), pp. 207–18.

[13] H. E. Winlock, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1924–1925*, p. 7, fig. 3.

Eighteenth Dynasty, one 'showing two series of accordion-pleatings at right angles to each other being specially remarkable.'[1]

Wool

Although there are very few instances of wool having been found in Egyptian tombs until a late date, there cannot be any doubt that the Egyptians, who possessed large flocks of sheep, made use of wool as a covering. Herodotus mentions the wearing of loose, white woollen mantles over linen tunics[2] and Diodorus states that the Egyptian sheep yielded wool 'for clothing and ornament.'[3]

Woollen garments have been found in graves of the early Christian period,[4, 5, 6, 7] and the use of coloured wool at this date for the decoration of linen fabrics is fairly common. The few finds of wool of earlier dates that can be traced are, in chronological order, as follows, namely one predynastic example of 'brown and white woollen knitted stuff'[8]; one specimen found in the pyramid of Mycerinus at Giza, recorded as 'part of a skeleton . . . enveloped in coarse woollen cloth of a yellow colour,'[9] which was almost certainly an intruded burial of much later date than the pyramid; one specimen from the Twelfth Dynasty found by Petrie,[10] who says regarding it, 'wool was also spun; a handful of weaver's waste is mainly made up of blue worsted ends and blue wool, with some red and some green ends. A lump of red dyed wool, not yet spun, was found'; Brunton found yellow wool from the Second Intermediate period[11]; and there is a woollen netted turban of pre-Christian Roman date,[12] with reference to which, Winlock, the finder, says, 'Apparently it was the style in Thebes just before the Christian era to swathe the hair in fine linen veils until the head was twice its natural size, and then over that to pull such a netted brown and red turban, tied behind with drawing-strings'; and woollen fabrics were

[1] The Egyptian Museum, Cairo, *A Brief Description of the Principal Monuments*, 1932, p. 98 (No. 6094).
[2] II: 81. [3] I: 6.
[4] G. A. Reisner, *Arch. Survey of Nubia, Report for 1907–1908*, I, p. 107.
[5] C. M. Firth, *Arch. Survey of Nubia, Report for 1908–1909*, pp. 36, 91, 96.
[6] C. M. Firth, *Report for 1910–1911*, pp. 98, 124, 190.
[7] G. Brunton, *Qau and Badari*, III, p. 26.
[8] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 24.
[9] H. Vyse, *The Pyramids of Gizeh*, II, p. 86.
[10] W. M. F. Petrie, *Kahun, Gurob and Hawara*, p. 28.
[11] W. M. F. Petrie and G. Brunton, *Sedment*, I, pp. 17–20.
[12] H. E. Winlock, *The Egyptian Expedition 1924–1925*, in *Bull. Met. Mus. of Art, New York*, II (1926), pp. 31–2.

found by Brunton at Mostagedda of early Roman, later Roman and Coptic dates.[1]

Cotton

The home of the cotton industry is undoubtedly India, from which it spread westwards, and woven cotton fabric has been found at Mohenjo-daro in India which is dated between 2750 B.C. and 3250 B.C.[2]

Schoff states[3] that 'Cotton thread and cloth are repeatedly mentioned in the laws of Manu, 800 B.C.'

Herodotus (fifth century B.C.) states that in India 'there grows on wild trees wool more beautiful and excellent than the wool of sheep; these trees supply the Indians with clothing.'[4] Also 'The Indians wore garments of tree-wool.'[5]

On an Assyrian cylinder of the time of Sennacherib (seventh century B.C.) 'trees that bear wool' are mentioned.[6]

Theophrastus (fourth to third century B.C.) states that the island of Tylos (i.e. Bahrein) in the Arabian (i.e. Persian) Gulf 'produces the wool-bearing tree in abundance' and refers to fabrics being woven from it[7]: he also says that 'This tree is also found in India as well as in Arabia.' Pliny (first century A.D.) copies this description of cotton from Theophrastus, but contrasts the trees that bear 'wool' (cotton) with those that bear 'Seres' (i.e. mulberry trees with silk cocoons on them).[8]

Herodotus (fifth century B.C.) relates that two linen corslets given by the Egyptian king Amasis of the Twenty-sixth Dynasty (about 569 to 525 B.C.), one to the Samians or Lacedaemonians and the other to a temple in Lindus, were embroidered in cotton.[9]

Pliny (first century A.D.) states that 'The upper part of Egypt, in the vicinity of Arabia, produces a shrub known by the name of *gossypium*'[10] and that 'the most esteemed vestments worn by the priests of Egypt are made of it.'[10] This same author also says that 'Ethiopia, which borders Egypt, has in general no remarkable trees

[1] G. Brunton, *Mostagedda*, pp. 138, 139, 142, 143.
[2] Sir J. Marshall, *Mohenjo-daro and the Indus Civilization*, pp. VI, 33, 194. E. Mackay, *The Indus Civilisation*, pp. 103, 107, 137–8.
[3] W. H. Schoff, *The Periplus of the Erythraean Sea*, p. 71.
[4] III: 106. [5] VII: 65.
[6] L. W. King, in *Proc. Soc. Biblical Arch.*, XXXI (1909), pp. 339–43.
[7] *Enquiry into Plants*, IV: 7, 7, 8. [8] XII: 21.
[9] III: 47. [10] XIX: 2.

with the exception of the wool-bearing ones . . .'[1] Pliny, however, is by no means a paragon of detailed accuracy.

The earliest cotton fabrics that can be traced in Egypt are of the Roman period from Karanog in Nubia. These were originally reported as linen,[2] but they have since been examined by experts and are undoubtedly cotton.[3] It is thought that they may have been of Sudanese origin, more particularly because Reisner discovered cotton fabrics at Meroe in the Sudan of Graeco-Roman date,[4] and because there are early literary references to the use of cotton in Nubia, one about 250 A.D. and the other about eight centuries later.[5] R. Pfister, who has made a study of early Egyptian fabrics, informs me that woven cotton fabrics were not known in Egypt until a date several centuries after the Arab conquest (640 A.D.) and that the earliest known were not woven in Egypt.[5]

Silk

The silk industry had its origin in China and probably the material first reached the Mediterranean countries by way of Persia. Silk was not used in Egypt until late and the earliest reference to its use that can be traced is that of Lucanus (middle of first century A.D.), who describing Cleopatra says ' her white breasts resplendent through the Sidonian fabric, which, wrought in close texture by the skill of the Seres, the needle of the workman of the Nile has separated, and has loosened the warp by stretching out the web.'[6] A portion of a coloured silk fabric has recently been found at Kostol, south of Abu Simbel, the exact date of which is not yet certain, though probably not earlier than the fourth century A.D.[7] This, which was examined by me, was not a mulberry silk (i.e. the fibres were not those of the caterpillar *Bombyx mori*) but a ' wild silk ' of the nature of Tussah silk. A blue

[1] XIII: 28.

[2] C. L. Woolley and D. Randall MacIver, *Karanog, The Roman-Nubian Cemetery*, pp. 27, 28, 245 (G. 394, G. 531, G. 7511), Pl. 108, fig 1.

[3] F. Ll. Griffith and Mrs. C. M. Crowfoot, On the Early Use of Cotton in the Nile Valley, *Journal of Egyptian Archaeology*, XX (1934), pp. 5–12.

[4] R. E. Massey, A Note on the Early History of Cotton, *Sudan Notes and Records*, VI (1923), pp. 231–3. Mr. Massey kindly gave me his specimens and microscope slides when he was leaving the Sudan and I was able to confirm his conclusions.

[5] R. Pfister, L'introduction du coton en Égypte musulmane, *Revue des arts asiatiques*, XI (1937), pp. 167–72.

[6] *Pharsalia*, X: 141, quoted by W. H. Schoff, *op. cit.*, p. 265.

[7] W. B. Emery, *The Royal Tombs of Ballana and Qustul*, p. 385.

and red coloured silk border to a garment of Roman date was found by Brunton in Upper Egypt.[1] From the fourth century A.D. onwards silk becomes more common.

Grass and Reed.

The use of grass and reed for matting has already been mentioned, but these materials were used also for woven fabrics other than matting. Midgley states[2] that some of the predynastic woven fabrics, thought at first to be linen, were probably not linen, and of some material found at Armant he says[3] 'The microscopic structure of the fibre is similar to that used in some Badarian cloths.' 'It is apparently some fibro-vascular tissue not in any way related to flax.' Some of the specimens he says[3] were 'spun from reed fibre . . .' and again others 'are made from yarns of grass or reed fibre . . .' Also, 'The fibres from Mostagedda show quite conclusively that from Badarian until early Roman times vegetable fibres other than flax had been used . . .'[3] Manifestly much more work is required before the whole history of the fibres employed in ancient Egypt for weaving is known.

Hemp.

With respect to the use of hemp for woven fabrics in ancient Egypt, Midgley says[4] 'Hemp is the type "A" fibre which is found in the Badarian, Predynastic, and Pan-grave cloths, and I find it in the Dynastic fabrics from the Badarian sites also.' Again, of certain woven fabrics of Roman date, he says[4] that 'it is certain that the yarn is made from hemp.' The botanical source of the hemp is not specified, but the name is applied to a large number of bast fibres from different plants, one at least of which, for instance Deccan hemp (*Hibiscus cannabinus*), grows in Egypt.

Ramie

Midgley reports ramie fibre in a fabric of predynastic date,[5] but the copy of the photomicrograph published is far from convincing and

[1] G. Brunton, *Qau and Badari*, III, p. 26.

[2] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 67; G. Brunton, *Mostagedda*, pp. 145–6.

[3] Sir R. Mond and O. H. Myers, *The Bucheum*, I, pp. 71–2.

[4] G. Brunton, *Mostagedda*, p. 145.

[5] W. W. Midgley, (*a*) *Heliopolis, Kafr Ammar and Shurafra*, W. M. F. Petrie and E. Mackay, p. 50; Pl. LVIII; (*b*) *The Labyrinth, Gerzeh and Mazghuneh*, W. M. F. Petrie, G. A. Wainwright and E. Mackay, p. 6.

that the material was indeed ramie needs confirmation, more particularly as ramie fibre is a native of China and therefore most improbable in Egypt at that early date.

Dyeing

The art of dyeing was known in Egypt as early as the predynastic period, as matting of that date dyed red at the edges has been found.[1] Very little is known about either the nature of the dyes used or their methods of use, though, since artificial dyes are modern, the ancient Egyptian dyes must have been natural colours, and probably they were largely, if not wholly, of local origin.

Two papyri written in Greek, dating from about the third or fourth century A.D., which were found in Egypt, probably at Thebes, describe the process of dyeing and the nature of the colours used at that period. These are Papyrus X, now in Leyden, which has been translated by Berthelot,[2] and Papyrus Holm, now in Stockholm, which has been published by Lagercrantz.[3] These two papyri, so far as they deal with dyes and dyeing, have been made the subject of a special study by Pfister.[4]

Five principal dyes are mentioned, which have been identified as archil (orchil), a purple colour derived from certain marine algae found on rocks in the Mediterranean Sea[5]; alkanet, a red colour prepared from the roots of *Alkanna tinctoria*; madder, a red colour extracted from the roots of *Rubia tinctorium* and *Rubia peregrina*, both Alkanna and Rubia being common in the Mediterranean region and, according to Muschler,[6] both having been found growing in Egypt, and Oliver mentions *Alkanna tinctoria* as growing in the desert west of Alexandria[7]; kermes, a red colour from the dried bodies of a certain female insect, *Coccus ilicis*, found on an evergreen oak that grows in

[1] G. A. Reisner, *The Arch. Survey of Nubia*, I, p. 124, No. 81.

[2] M. Berthelot, *Collections des anciens alchimistes grecs*, 1887.

[3] O. Lagercrantz, *Papyrus Graecus Holmiensis*: Recepte für Salber, Steine und Purpur, Upsal, 1913.

[4] R. Pfister, Teinture et alchimie dans l'orient hellénistique, *Seminarium Kondakovianum*, VII (1935), Praha.

[5] Modern archil is obtained from lichens growing on trees in Florida.

[6] R. Muschler, *Manual Flora of Egypt*, II, pp. 798, 919. See also G. Schweinfurth, Sur la flore des anciens jardins arabes de l'Égypte, *Bull. de l' Inst. Egyptien*, 2nd Series, 8 (1887), p. 327.

[7] F. W. Oliver, The Flowers of Mareotis, *Trans. Norfolk and Norwich Naturalists' Society*, XIV (1938).

north Africa and south-east Europe, and woad, a blue colour obtained by a process of fermentation from the leaves of *Isatis tinctoria*.[1]

Herodotus states[2] that ' Libyan women wear hairless tasselled goat-skins over their dress, coloured with madder.'

Loret has identified what he believes to be the ancient Egyptian names for alkanet and madder.[3]

The different dyes may be considered conveniently in alphabetical order of colour.

Blue.

The ancient Egyptian blue has always been called indigo, meaning *Indigofera tinctoria*, imported from India, and Thomson, about one hundred years ago, identified it on ancient Egyptian fabrics,[4] but unfortunately the date of the material is not stated. I, too, found what I thought at the time was Indian indigo on an ancient Egyptian fabric (undated) and others also have reported Indian indigo from Egyptian fabrics. Indigo, however, is produced from a great variety of plants of which the two principal are Indian indigo from the leaves of *Indigofera tinctoria*, and woad, from the leaves of *Isatis tinctoria*, the colouring matter of both of which, if not absolutely identical, is so much alike that it is difficult, if not impossible, to distinguish between them. The dye does not occur ready formed in the plant, but is obtained by the artificial fermentation of the leaves, which contain a constituent that becomes converted into indigo.

Indigo was cultivated in Egypt during the last century, but this cultivation probably does not date back earlier than the Middle Ages.[5] Maqrisi (fourteenth century A.D.) says[6] that indigo was cultivated in Egypt in his day. The locally-made dye has now been replaced by imported artificial indigo. The former cultivated indigo was *Indigofera argentea*,[5] a species that grows wild in Nubia, Kordofan, Sennar and Abyssinia, though sometimes it is said to have been the Indian indigo *Indigofera tinctoria*.[7]

With respect to a blue colour on a tunic from the tomb of

[1] Pfister calls this indigo. [2] IV: 189.

[3] V. Loret, *Kemi*, III (1930–35), pp. 23, 32.

[4] J. Thomson, *London and Edinburgh Phil. Mag.*, 5, 1834.

[5] G. P. Foaden and F. Fletcher, *Text-Book of Egyptian Agriculture*, II, 1910, p. 513. V. Loret, *La flore pharaonique*, 2nd ed., p. 90.

[6] V. Bouriant, *Mém. de la mission arch. franç. au Caire*, 1900, p. 201.

[7] P. S. Girard, *Description de l'Égypte, état moderne*, II, 1812, p. 545.

Tut-ankhamun, Mrs. Crowfoot writes[1] 'The blue, which was not examined, is as he (i.e. Pfister) says, undoubtedly indigo, but I do not agree with him that the plant used was woad, *Isatis tinctoria, L.*, I suggest that a more probable source was *Indigofera argentea, L.* (. . .) which is cultivated and sub-spontaneous in Lower Egypt and the Sudan, unless indeed *Indigofera tinctoria, L.*, so widely exported later, had already been brought from India.' Although *Indigofera argentea* is sub-spontaneous in Lower Egypt and indigenous in Upper Egypt, it it not likely to have been used as a dye until it was cultivated, for which there is no evidence before the Middle Ages.

Woad was certainly cultivated in the Fayum province of Egypt in early Christian times, that is from the first to the fourth century A.D.,[2] and probably earlier, and, therefore, what has been assumed to have been Indian indigo on ancient Egyptian fabrics may have been woad, more particularly since Indian indigo, although known to the Romans of Pliny's time,[3] was only used as a pigment for painting and not as a dye. Vitruvius (first century B.C.) mentions the scarcity of indigo and the use of woad as a substitute in painting.[4]

Pfister examined a large number of dyed woven woollen fabrics chiefly from Arsinoë in Upper Egypt, ranging in date from the third century A.D. to the seventh century A.D., on which he identified the blue colour as woad, which, however, he calls indigo.[5]

Winlock, writing of a blue dye of late Eighteenth Dynasty date, says[6] that it 'was probably the juice of the sunt berry (*Acacia nilotica*), but the evidence is not given, and the sunt has a pod with seeds and not berries.

Black.

Although on several of the dyed fabrics from the tomb of Tuthmosis IV (Eighteenth Dynasty) there is a colour that appears to be black, yet from a careful examination of these fabrics it appears probable that the original colour may have been dark brown. The nature of the

[1] G. M. Crowfoot and N. de G. Davies, The Tunic of Tutankhamun, *Journal of Egyptian Archaeology*, 27 (1941), pp. 113–30.

[2] B. P. Grenfell and A. S. Hunt, *The Oxyrhynchus Papyri*, I, pp. 164, 166; II, pp. 270, 271; III, p. 282; IV, pp. 215–21; X, pp. 221–2; XIV, pp. 147–8; A. S. Hunt, *op. cit.*, VII, pp. 205–6.

[3] XXXIII: 57; XXXV; 25, 27.

[4] *On Architecture*, VII: XIV, 2.

[5] R. Pfister, (*a*) *op. cit.*, pp. 40–1; (*b*) *Tissus Coptes du Musée du Louvre.*

[6] H. E. Winlock, Materials used at the Embalming of King Tut-ankh-amun, *Paper No. 10, Met. Mus. of Art, New York*, 1941.

colour was not determined, but possibly it may have been made by imposing red on blue.

Brown.

Pfister suggests[1] that perhaps the brown colour on some of the Antinoë fabrics may be catechu (cutch), which is prepared from the Mimosa catechu grown in India and there used for dyeing cotton, but this seems most unlikely.

Green.

In one instance,[2] Pfister found a green colour to be due to indigo (woad) together with a yellow colour, the nature of which could not be determined. I found that a green colour on thin plaster on a stick from the tomb of Tut-ankhamun consisted of a mixture of blue (blue frit) and a yellow, not identified.

Purple.

Pfister found[3] that the purple colour on the Antinoë fabrics was madder on indigo (woad).

Red.

On the Antinoë fabrics this was generally madder, but occasionally kermes,[4] with two instances of what Pfister calls cochineal or sometimes Persian cochineal.[5] It cannot, of course, have been the modern cochineal, since this originally came from Mexico and was not known in Egypt at the time. A red-brown colour on one of the fabrics from the tomb of Tut-ankhamun was identified by Pfister as madder.[6] An orange-red colour on mummy wrappings of Twenty-first Dynasty date[7] Pfister found to be due to henna,[8] probably mixed with a red colour obtained from the flowers of *Carthamus tinctorius*.[9] This latter plant grew abundantly in ancient Egypt and is still plentiful, and from

[1] R. Pfister, (*a*) *op. cit.*, pp. 41–2; (*b*) *Tissus Coptes du Musée du Louvre.*

[2] R. Pfister, *op. cit.*, p. 42.

[3] R. Pfister, (*a*) *op. cit.*, pp. 39–40; (*b*) *Tissus Coptes du Musée du Louvre.*

[4] R. Pfister, (*a*) *op. cit.*, pp. 37–9; (*b*) *Tissus Coptes du Musée du Louvre.*

[5] R. Pfister, *op. cit.*, p. 46.

[6] R. Pfister, Les textiles du tomb de Toutankhamon, *Revue des arts asiatiques*, XI (1937), p. 209.

[7] G. Maspero, *Mém. de la mission arch. franç. au Caire*, I (1889), Les momies royales de Deir el Bahari, pp. 537, 539, 563, 768.

[8] Descotiles and Berthelot stated that henna was employed for dyeing mummy wrappings. *Memoirs relative to Egypt.*

[9] R. Pfister, *Les textiles du tombeau de Toutankhamon*, p. 210. Also G. Schweinfurth, *Bull. de l'inst. Egyptien*, 1882.

the flowers both a red and a yellow dye are obtained. The yellow is not now used, as it is soluble in water and, therefore, not permanent, but the red is insoluble in water though soluble in dilute solutions of alkali, such as natron, and has been employed in modern times for dyeing silk, as also for colouring starch to make rouge for toilet purposes, and the deep-red flower petals are used sometimes for colouring soup. Girard states[1] (1812) that the flowers were employed for dyeing.

Yellow.

Many years ago Thomson suggested that the yellow dye of the ancient Egyptians was derived from the safflower, but he was unable to prove this,[2] though it has since been established definitely by Hübner,[3] who identified it on fabrics of Twelfth Dynasty date. Hübner found also that another and slightly different shade of yellow of the same date was iron buff.[3]

Mordants

In the process of dyeing generally two mediums are necessary, one being the colour and the other an agent, or mordant, as it is called, to fix the dye to the fabric, and in Egypt, although probably at first mordants were not used, by Pliny's time (first century A.D.) a mordant was certainly employed and is referred to by that author, who states[4] that 'In Egypt, too, they employ a very remarkable process for the colouring of tissues. After pressing the material, which is white at first, they saturate it, not with colours, but with mordants that are calculated to absorb colour. This done, the tissues, still unchanged in appearance, are plunged into a cauldron of boiling dye, and are removed the next moment fully coloured. It is a singular fact, too, that although the dye in the pan is of one uniform colour, the material when taken out of it is of various colours, according to the nature of the mordants that have been respectively applied to it: these colours, too, will never wash out.' Unfortunately the nature of the mordants is not mentioned, though the principal one was almost certainly alum, which occurs in Egypt and which was worked anciently.[5]

[1] P. S. Girard, *op. cit.*, pp. 538–9.

[2] J. Thomson, *op. cit.*

[3] J. Hübner, The Colouring Matter of the Mummy Cloths, *The Tomb of Two Brothers*, pp. 70–7, M. A. Murray. See also R. Pfister, *Tissus Coptes du Musée du Louvre.*

[4] XXXV: 42.

[5] See p. 291.

According to the two papyri already mentioned the mordants used in Egypt in early Christian times included alum, but also salts of iron, such as the acetate, specially prepared from iron and vinegar, and the sulphate, which occurs frequently as an impurity in the alum.[1]

The remains of a dye-house of Roman date were found by Petrie at Athribis, near Sohag, who states[2] 'These vats . . . most of them are blue-black with indigo and some red.' The Italian archaeological Mission found at Tebtunis (Kom el Breigat) 'a Roman fullonica, or dyeing and cleaning works, very similar to the modern Egyptian ones.'[3]

[1] R. Pfister, *Tissus Coptes du Musée du Louvre.*
[2] W. M. F. Petrie, *Athribis*, p. 11.
[3] *Egyptian Gazette*, April 23rd, 1935.

CHAPTER IX

GLAZED WARE[1]

The sequence which at present obtains for glazed ware from ancient Egypt is—first, glazed steatite from the Badarian civilization[2]; second, glazed powdered quartz (faience) from the predynastic period, sequence date 31,[3] a number of variants of which came in later; third, glazed solid quartz, also from the predynastic period, but sequence date 48,[3] and fourth, glazed pottery from the Arab period. This sequence, however, is liable to be upset at any time by fresh discoveries, and the natural sequence would seem to be—first, glazed solid quartz, which is the most likely to have been discovered accidentally and to have formed the starting-point for glazed ware; second, glazed quartz powder, the powdering and moulding, or other shaping, of quartz being an ingenious method of avoiding the cutting of such a hard stone; third, glazed steatite, which is merely the substitution of a natural soft stone, that can easily be carved, for a hard stone that can only be cut with difficulty; and fourth, glazed pottery. It seems highly probable, however, that at a very early date attempts were made to glaze pottery, which would have made it not only decorative but also impermeable to liquids, a very desirable property, but any such attempts must have ended in failure, since the only glaze known was an alkaline one, which will not adhere to ordinary clay ware, the lead glaze that will adhere not having been discovered until much later.[4]

The various kinds of glazed ware enumerated will now be described in order of sequence.

[1] Since the materials are being dealt with in alphabetical order, glazed ware should come after glass, but, as it was from glazed ware that glass developed, the natural order is being used in this instance. This chapter is taken in part from an article by me published in *The Journal of Egyptian Archaeology*, XXII (1936), pp. 141–64.

[2] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 27, 28, 41.

[3] W. M. F. Petrie, *Prehistoric Egypt*, p. 42.

[4] Occasionally pottery was coated with an ordinary resin varnish. The few specimens examined have all been from the Eighteenth Dynasty.

A. Glazed Steatite

The earliest glazed material of any kind known from ancient Egypt is steatite, beads of which were very plentiful in the Badarian civilization. Brunton, who found them, suggests that they 'can hardly have been made locally.'[1] This, of course, may be so, but it should not be forgotten that steatite is found in Egypt, and that there is a deposit at Gebel Fatira less than 100 miles from El Badari, slightly to the south-east between the Nile and the Red Sea. Another occurrence of steatite is at Hamr, near Aswan, where there is evidence of ancient working, and a third in Wadi Gulan, opposite Gulan Island, north of Ras Benas on the Red Sea coast.

Steatite is a massive form of talc, and consists of hydrated magnesium silicate; it can easily be cut with a knife, or scratched with the finger-nail, its hardness on Mohs' scale being only 1. Its specific gravity is 2.7 to 2.8; it is usually white or grey in colour, though occasionally smoke-black.

Steatite is a very suitable material for carving into small objects such as amulets, beads, scarabs (the greater proportion of which are of steatite), small statuettes, and small vases, not only on account of its softness and the consequent ease with which it can be cut, but also because it is fine-grained. It possesses a further quality that makes it satisfactory as a base for glazing, namely, infusibility, and not only may it be heated without decomposition or fracture, but the heating, by dehydrating it, causes it to become hard enough to scratch glass.[2]

Glazed steatite continued in use until the 'Arab age,'[3] but glazed scarabs of this material are still being made by the modern forgers of antiquities at Qurna near Luxor.

B. Faience

By 'Egyptian faience' is meant glazed quartz frit (powdered quartz) ware. 'Glazed siliceous ware,' suggested by Burton,[4] is too vague, since it would include glazed siliceous pottery. The term 'glazed pottery' often used to describe Egyptian faience is entirely wrong and

[1] G. Brunton and G. Caton-Thompson, *op. cit.*, p. 41.

[2] See also H. C. Beck, *Notes on Glazed Stones*, Part I, *Glazed Steatite*, in *Ancient Egypt and the East*, 1934, pp. 69–75, and F. A. Bannister and H. J. Plenderleith, *Journal of Egyptian Archaeology*, 22 (1936), pp. 2–6.

[3] W. M. F. Petrie, *Prehistoric Egypt*, p. 42.

[4] W. Burton, *Ancient Egyptian Ceramics*, in *Journal, Royal Society of Arts*, 60 (1912), p. 596.

misleading, pottery being ware made from clay, shaped while wet and then hardened by baking. The term 'glaze' sometimes used is also wrong, and it would be just as reasonable to call a varnished object 'varnish' as to call a glazed object 'glaze.' Faience may be classified into ordinary faience and a number of variants, all of which may now be described.

Ordinary Faience

Typical Egyptian faience consists of a body material (core) coated with a vitreous, alkaline glaze, and it ranges in date from predynastic times[1] to as late as the fourteenth century A.D.[2]

Body Material

This is always granular, generally friable and often very friable, though sometimes hard, and usually very finely divided, but occasionally comparatively coarse. It is frequently white, or practically white, in colour, but sometimes tinted brown, grey, or yellowish and occasionally very slightly blue or green.[3]

Many hundreds, and probably thousands, of specimens of ordinary faience have been examined, but no useful purpose would be served by giving the details of them all, though the colour of the body material of a few may be recorded. Thus, forty-one specimens from the First and Second Dynasties, now in the Cairo Museum, which are important because they belong to a comparatively early period in the history of the material, are as follows:

Colour of Core	*Number*	*Per cent.*
Very white	8	20
Grey	3	7
Slightly yellow	11	27
Light to dark brown[4] . . .	19	46
	41	100

Some Third Dynasty small blue tiles from the Step Pyramid at Saqqara and from the adjoining large tomb have a very fine white core; a number of pieces of inlay from the palace at El Amarna

[1] W. M. F. Petrie, *Prehistoric Egypt*, p. 42. [2] See p. 192.

[3] This is friable and not the hard blue or green body material described later as Variant D: it has been noticed from the Eighteenth Dynasty.

[4] The colour suggests the use of powdered sand or sandstone.

(Eighteenth Dynasty) have a coarse white core; the Nineteenth-to-Twentieth Dynasty specimens from Qantir[1] have a coarse brown core; of eighteen Graeco-Roman specimens from the Fayum twelve have a white, or practically white, core, five have a brown core and one a grey core, and four specimens of Islamic faience have a very white core.

The body material, whether fine or coarse, is seen when examined microscopically to consist of sharp, angular grains of quartz, without any visible admixture of other substance.

Only very few chemical analyses of this material can be traced, and of these many are unsatisfactory because no particulars of the kind or date of the specimens are given, while in some instances the material analysed was manifestly not ordinary faience but one of the variants.[1]

For the white body material only three origins seem possible, namely, powdered quartz rock, powdered rock crystal, or powdered white quartz pebbles, from all of which I have prepared by fine grinding a material practically identical with the ancient material. At least one of the modern forgers of faience uses both powdered quartz rock and powdered rock crystal.

For the brown, grey, and yellowish body material, powdered sand, sandstone, or flint seem likely, the colour being due to natural impurities in the material employed.

Glaze

The glaze, which is most frequently coloured blue, green, or greenish-blue, but is sometimes violet, white, yellow, or of two or more colours,[2] is what is termed an ' alkaline ' glaze, and consists of glass; chemically it is essentially a sodium-calcium-silicate or a potassium-calcium-silicate without any lead compound.[3] Only two complete analyses of the glaze, of which sufficient details are given to make it certain that the specimen was from ordinary faience, can be traced.[4]

From the results of the analyses it is evident, first, that not only is the glaze glass but it is of similar composition to the ancient glass, except that the proportion of lime (calcium oxide) is lower and that of silica higher than is usual in the ancient glass; and second, that the colour, like that of much of the glass, is due to a copper compound.

[1] For analyses see pp. 535–6.
[2] Black and red faience are described on pp. 185–7.
[3] For the reason for emphasizing this see p. 190.
[4] For analyses see p. 536.

The large amount of potash and the small amount of soda present in one specimen show that the alkali employed for this particular glaze was plant ashes and not natron.

A partial analysis of the blue glaze on a predynastic chert bead made by Sir Herbert Jackson for Mr. Horace Beck showed that it consisted essentially of sodium silicate, with merely a trace of calcium, coloured with a copper compound.[1] In this instance, since the alkali was soda, the source of it must have been either natron or the ashes from special plants grown near salt water.[2]

Brongniart states[3] that the glaze of Egyptian faience was examined by Buisons, Laurent, Malaguti, and Salvétat, and that it consists of silica and soda coloured with a copper compound. Franchet also says[4] that it consists of a compound of silica and soda.

Shaping

The next question to be considered is how such a material as powdered quartz was shaped. Burton's suggestion[5] that faience objects were carved out of sandstone cannot be accepted for many reasons, chiefly because the material has not the naturally rounded grains of sandstone, but sharp angular grains that prove it to be artificially prepared and because no such fine white sandstone is known, but also because the body material of faience is usually so friable that carving would have been impossible. The question, however, has been partly settled by the discovery of very large numbers of red pottery moulds, though none earlier than the Eighteenth Dynasty. Petrie 'brought nearly five thousand from Tell el Amarna after rejecting large quantities of the commonest'[6]; Winlock mentions 'hundreds of moulds for beads, pendants and finger rings' from the factories in the palace area of Amenophis III[7]; and Mahmud Hamza collected 'about ten thousand,' of Nineteenth or Twentieth Dynasty date from Qantir, 'most of which still bear traces of the colour and the paste used in the process of manufacture'[8]: 'At Naukratis hundreds were found

[1] H. C. Beck, *Notes on Glazed Stones*, Part II, *Glazed Quartz*, in *Ancient Egypt and the East*, 1935, p. 23. [2] See p. 197.

[3] A. Brongniart, *Traité des arts céramiques ou des poteries*, I, p. 506.

[4] L. Franchet, *Céramique primitive*, p. 92.

[5] W. Burton, *op. cit.*, pp. 594–9.

[6] W. M. F. Petrie, *Tell el Amarna*, p. 30.

[7] H. E. Winlock, *Bull. Met. Museum of Art, New York*, VII (1912), p. 187.

[8] M. Hamza, Excavations of the Department of Antiquities at Qantir, *Annales du Service*, XXX (1930), p. 42.

for making scarabs for the Greek trade'[1]: 'Such moulds have been found in many other places, Memphis, Thebes, Gurob, etc.'[2] Writing of these moulds, Petrie says[1] 'They sometimes contain the remains of the siliceous paste with which they were choked when they were thrown away.' Most of the moulds referred to are for small objects, ornaments, pendants and scarabs, but there are also larger ones for *shawabti* and other figures. All the moulds found have been open, that is they are for one side (the front) of the object only. Petrie states[3] that the 'paste was roughly moulded into form and when dry it was graved with a point to give detail' and also that large objects were made in sections, which were joined together with some of the same paste before glazing. Hayes says of the faience from Qantir that 'The statues and all the larger tiles were modeled by hand, not cast in molds . . . Each of the statues was built up in several masses of the body material on a core of wooden rods . . . the glaze (. . .) was applied as a viscous fluid.'[4] A certain proportion of the moulds have a narrow channel across the edges near the top of the mould in which a thick copper wire was placed. The mould was then filled with the plastic powdered quartz paste above the level of the wire. After firing, the wire was removed, leaving a hole in the object from one side to the other that could be used for suspension. One such wire, now very corroded, was found by Hamza at Qantir and is in the Cairo Museum.[5] The length is 8.1 centimetres and the diameter in its corroded state varies from one to two millimetres. The channels for the wire are apparently what Petrie calls 'ducts at the side for the outflow of the surplus material.'[6] Faience objects, however, were not always moulded, as Reisner states[7] that the thin bowls, the larger jars and some of the other jars from the Middle Kingdom Egyptian colony at Kerma in the Sudan had been turned on the wheel; that most of the smaller jars had been made on a core; that a few poor jars showed traces of gouging as if they had been formed solid and dug out while still moist; that figures and amulets had been modelled by hand and finished with a point or blade, and that none of the objects had been made in moulds; and I would venture to suggest that bowls and vases, especially such as

[1] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, pp. 118–9.
[2] W. M. F. Petrie, *Tell el Amarna*, p. 30.
[3] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, pp. 115–6.
[4] W. C. Hayes, *Glazed Tiles from a Palace of Ramesses II at Kantir*, p. 8.
[5] No. J. 64523. [6] W. M. F. Petrie, *Naukratis*, I, p. 37.
[7] G. A. Reisner, *Kerma*, IV–V, p. 137.

the libation vases of 'teapot' form, could only have been made by pottery methods and not by moulding, though the spouts and lids may have been moulded.

Faience with Extra Layer (Variant A)

Occasionally, instead of there being only two layers of material, namely an inner core coated with glaze, there is also an additional layer between the core and the glaze. This extra layer was first pointed out by Reisner,[1] whose description of it is the only one that I can trace. Any generalization with respect to the prevalence of this special layer would be dangerous without the examination of more specimens of faience of different kinds and dates than usually fall to the lot of any individual to handle, more especially as it is only with broken objects (which generally are not to be found on exhibition in museums) that its presence or absence can be detected; however, the writer's experience may be given. In addition to the occurrence of this layer in the Twelfth Dynasty faience from Kerma described by Reisner, it is also present in faience of the same period from Shalfak (Sarras), also in the Sudan, specimens of both of which I have examined; it was not present in forty-one specimens from the First and Second Dynasties; nor in the Third Dynasty blue tiles from Saqqara; nor in several specimens of the Twelfth Dynasty from Lisht; nor in one specimen of the same date from El Barsheh; and it was found only in one specimen (part of a blue-glazed tile from Deir el Bahari) out of several hundreds examined from the Eighteenth Dynasty, though it was present on several undated specimens probably from that Dynasty; it was rarely present in the late material, only comparatively few examples having been found out of many hundreds of specimens examined, these being (*a*) a few pieces of the coarse brown-body material found by Mahmud Hamza at Qantir[2]; (*b*) one lot of *shawabti* figures of Twenty-sixth Dynasty date, and (*c*) two pieces of Graeco-Roman date out of many from the Fayum. It was not present on four specimens from the Arab period.

The extra layer, in those instances in which it has been measured (which, however, seem typical of the rest), varied in thickness from about 0.5 mm. to about 2.5 mm. In a Kerma specimen it was white on a light-grey body, and, as Reisner states, very like plaster of Paris

[1] G. A. Reisner, *Excavations at Kerma*, IV–V, pp. 134–75.

[2] M. Hamza, Excavations of the Department of Antiquities at Qantir, *Annales du Service*, XXX (1930), pp. 31–68.

in appearance; in a Shalfak specimen it was white on a light-blue body; on the Eighteenth Dynasty tile mentioned it was white on a faintly blue-tinted body; on the Qantir specimens it was white on a brown body; on the Twenty-sixth Dynasty *shawabti* figures it was white on a dark-grey body; on one of the Graeco-Roman specimens it was white on a reddish body and on the other it was white on a grey body, and in every instance in which it has been critically examined the extra layer has consisted of very finely powdered quartz, always more finely ground and more compact than the body substance. There can be little doubt that, as stated by Reisner, the special layer was employed for the purpose of enhancing or modifying the colour of the glaze. Thus, when a brown, grey, or yellowish body material would have lessened or spoilt the full brilliance of a blue glaze, a thin layer of a perfectly white material was interposed between the two; sometimes, when a green glaze was required, a yellow layer was used underneath a blue glaze in order to give it a greenish tint, and in one specimen a white layer was used under parts only of a dark-blue glaze in order to give to those parts a lighter colour, thus forming a light-blue pattern on a dark-blue ground.

With respect to the method of applying the ' special ' layer, which consists of exceedingly finely ground quartz powder, it was found by experiment that a good, strongly adherent white layer of any thickness desired could be made by using a mixture of very fine quartz powder and natron solution, drying and firing. On account of the porosity of the body substance the mixture must not be too viscous (otherwise owing to abstraction of water by the quartz it becomes too thick to be laid on evenly) and if carefully poured on it forms a uniform layer with a flat surface, which when dried and fired becomes strongly adherent.

Black Faience (Variant B)

Black faience is not very common; it is known, however, in the form of a small tile[1] and small pieces of inlay[2] of Third Dynasty date from Saqqara; as small beads of early dynastic date[3] (Sixth, Eighth, and Ninth Dynasties), but in some instances the glaze was possibly originally

[1] D. Valeriani and G. Segato, *Atlante del Basso ed Alto Egitto*, 1835, Pl. T 37D.
[2] Cairo Museum, Nos. J. 69563 A, B, C; 69564 A, B, C, D, E, F, G; and 69565.
[3] Found by Mr. Guy Brunton (not yet all published), and examined by me. These are exclusive of the beads of black, glassy material described by H. C. Beck in G. Brunton, *Qau and Badari*, II, pp. 23, 24.

green that has changed to black; as beads of Middle Kingdom and Second Intermediate periods respectively[1]; as inlay from El Amarna (Eighteenth Dynasty) and Qantir (Nineteenth to Twentieth Dynasty) and in plaques from the palace of Ramesses III at Medinet Habu (Twentieth Dynasty). In the specimens examined (other than the beads, where the core was white) the core was either dark grey or dark brown, and consisted of the usual powdered quartz, coloured by means of oxide of iron. It is most probable that the oxide of iron was added intentionally, and, therefore, that the material is a definite variant.

Red Faience (Variant C)

Very occasionally red faience is merely ordinary faience having a red glaze on a white, or almost white, body, for instance two small oblong tiles and several pieces of tiles of Third Dynasty date from Saqqara, now in the Cairo Museum,[2] and two specimens, both of Eighteenth Dynasty date, from El Amarna. Usually, however, red faience is a definite variant, the body material being red and the glaze sometimes red and sometimes having very little colour.

Petrie states that 'Red varying between red brick and maroon belongs to Akhenaten and is seldom, if ever, found in the Ramesside and later times.'[3] Since this was written, however, much more red faience has been found, for example, the tiles already mentioned, as also a reference to similar red tiles, also of the Third Dynasty, from Saqqara[4]; a few red faience spheroid beads of the Second Intermediate period found by Brunton[5] and a very large amount of red faience from the Eighteenth, Nineteenth and Twentieth Dynasties respectively. From the Eighteenth Dynasty red faience occurs as beads, necklace-pendants, and inlay, such necklace-pendants and inlay being very common from El Amarna, and similar necklace-pendants having been found in the tomb of Tut-ankhamun; from the Nineteenth Dynasty (reign of Ramesses II) and Twentieth Dynasty (reign of Ramesses III) red faience foundation deposits are known; during the Nineteenth and Twentieth Dynasties red faience was used for beads and also for inlay in the Ramesside palace at Qantir, and during the Twentieth Dynasty

[1] G. Brunton, *Mostagedda*, pp. 114, 125, 126, 134.
[2] Nos. J. 69565, 69566 A, 69566 B, 69566 C, 69567, 69568.
[3] W. M. F. Petrie, Burlington Fine Arts Club, *Exhibition of the Art of Ancient Egypt*, 1895, *Glass and Glazing*, p. xxviii.
[4] D. Valeriani ed G. Segato, *loc. cit.*
[5] G. Brunton, *Mostagedda*, p. 126.

red faience inlay was employed in plaques in the palace of Ramesses III at Medinet Habu. Specimens of all of the above-mentioned objects in the Cairo Museum have been examined.

Several pieces of early dynastic faience in the Cairo Museum seem at first sight to have a red core with a blue or green glaze, but on further examination it is found that although the surface of the core of an old break is red or reddish, this coloration is only superficial, being due apparently to a surface oxidation of the iron compounds present, and underneath the red the colour is brown, owing possibly to the use of a brown sand.

With regard to the composition of the red body material, Petrie says: '. . . for the red, a body mixed with haematite and covered with a transparent glaze.'[1] A number of specimens have been analysed, all of which consisted of a very fine, red, gritty powder, which proved to be powdered quartz, coloured by means of red oxide of iron, and from a comparison of specimens of red quartz sand powdered to the same degree of fineness and examined both microscopically and chemically side by side, it is practically certain that the red body material of the faience is not a natural red sand finely powdered (which would give a red quartz powder) but an artificial mixture of quartz and red ochre, or other form of iron oxide.

Red faience is quite distinct from the red glazed pottery of the Arab period.

Faience with Hard Blue or Green Body (Variant D)

This consists of a core of granular quartz, generally harder than that of ordinary faience and sometimes very hard, tinted blue or green and always coated with a definite and separate glaze of the same colour as the core, though usually of a lighter shade. At first sight the colour of the core might appear to have been caused by some of the glaze having accidentally penetrated the body material, but against this there are two objections: first, that the glaze would probably have been too viscous to have penetrated[2] and, second, that if there had been any such penetration, it would have been greatest near the surface and would have progressively diminished towards the centre, whereas there is no such gradation of tint, which is generally uniform throughout, though occasionally there are tiny particles of darker-coloured blue or green material, looking like glaze, scattered through the core. Franchet

[1] W. M. F. Petrie, *Arts and Crafts of Ancient Egypt* (1910), p. 118.

[2] See p. 199, where penetration of glaze certainly occurred.

mentions this and says *que c'est, parfois, la glaçure bleue qui a été utilisée et on en distingue facilement les grains dans la masse de la pâte.* It seems likely, therefore, that a little finely powdered glaze, or a powdered mixture of the glaze materials, was deliberately mixed with the quartz, in order to make the fused object harder. Franchet makes a similar suggestion, and says that to overcome the fragility of ordinary faience glaze was mixed with the quartz of the body.[1] Although any admixed glaze would also act as a binder, it could only function in this capacity after the firing, and in the case of non-moulded objects the usual adhesive would still be required in order to enable the material to be shaped and glazed. Another possibility is that specimens of faience, accidentally damaged during making, or imperfect from other causes, may have been ground up, body and glaze together, to make a new body material. This variant of faience is generally attributed to the Twenty-sixth Dynasty but one piece of inlay of what apparently is this material is known from the Third Dynasty, having been found at Saqqara.[2] In addition to the examination of a large number of specimens with a lens, twelve examples have been examined microscopically.[3]

Glassy Faience (Variant E)

A further step in the evolution of faience resulted in the production of a material which, although manifestly derived from the variant of faience just considered (Variant D), does not come within the definition of faience given and, therefore, strictly speaking, is not faience at all, since it does not consist of a body material coated with a separate glaze, but is entirely homogeneous in composition throughout, without any separate coating of glaze,[4] though the outside is generally, but not always, glossy.[5] This also is attributed generally to the Twenty-sixth Dynasty. Thus Petrie says: 'In the XXVIth dynasty there is a beautiful hard stoneware, apparently made by mixing some glaze with the body, enough to fuse it together into a solid mass throughout.'[6] One specimen (part of a small bracelet) of what appears to be this

[1] L. Franchet (*a*) *Rapport sur une mission en Crète et en Égypte*, p. 116; (*b*) *Céramique primitive*, pp. 42, 101.

[2] Cairo Museum, No. J. 69562. [3] For chemical analyses see p. 536.

[4] Sometimes it is very difficult to be certain whether there is a thin separate glaze or not and to know into which class, Variant D or Variant E, to place a particular specimen.

[5] For chemical analyses see p. 536.

[6] W. M. F. Petrie, *Arts and Crafts of Ancient Egypt*, p. 116.

material of Third Dynasty date was found at the Step Pyramid at Saqqara.[1] It is without separate glaze, homogeneous throughout, of a light-grey-blue colour, fairly hard and not glassy.

As may be seen from the following tabular statement, beginning with ordinary faience, passing to the Variant D, then to the phase called by me Variant E, and finally to ordinary glass, the proportion of silica gradually becomes less, while that of the alkalies increases. The figures are:

	1 *Ordinary Faience* %	*2* *Variant D* %	*3* *Variant E* %	*4* *Glass* %	*5* *Glass* %
Silica . . .	94·4	94·0	88·6	62·2	60·9
Alkalies . .	1 1	1·7	5·8	19·9	28·7

No. 1. Mean of 7 analyses (see p. 535).
No. 2. Mean of 4 analyses (see p. 536).
No. 3. One analysis (see p. 536).
No. 4. Mean of 24 analyses (see p. 539).
No. 5. Mean of 13 analyses (see p. 537).

A number of specimens of this material have been examined. Under the microscope it is seen to be very granular and to consist of what, for want of a better term, may be called imperfect glass, that is glass in which there is too small a proportion of alkali to combine with all the quartz, so that on firing there has been incomplete fusion, with the result that a considerable proportion of the quartz grains remain uncombined and embedded in a matrix of glass.

Since this material is certainly not faience, and is equally certainly a kind of glass, though not normal glass, to call it 'glassy faience' or 'imperfect glass' seems to describe its nature and composition better than any other name that has been suggested.

Faience (Variant F)

Egyptian faience consists, as already shown, of a powdered quartz base coated with an alkaline glaze, and this continued to be made certainly as late as the fourteenth or fifteenth century A.D. At a late period, the exact date of which is not certain, but is probably about the Twenty-second Dynasty, a new glaze was introduced, which

[1] Cairo Museum, No. J. 69603.

contained a lead compound and which was occasionally applied to a powdered quartz base, and for a considerable period the two different glazes were used concurrently, both on a powdered quartz base, the older alkaline glaze, however, being by far the commoner of the two. At a later date the alkaline glaze was also occasionally employed on a very siliceous pottery base, that is to say on a base of burnt clay ware containing a large proportion of quartz, and lead glaze was commonly used on ordinary pottery (ordinary burnt clay ware).

Thus there were three different bases, namely powdered quartz, highly siliceous clay, and ordinary clay, and two glazes, an alkaline glaze and a lead glaze. Five different combinations of these are possible and were made, namely (*a*) an alkaline glaze on powdered quartz, that is to say ordinary faience; (*b*) an alkaline glaze on highly siliceous burnt clay ware (glazed siliceous pottery), which does not come within the definition of faience and will be considered later; (*c*) a lead glaze on powdered quartz, which is a variant of faience (Variant F), and will now be described; (*d*) a lead glaze on highly siliceous burnt clay ware (glazed siliceous pottery) and (*e*) a lead glaze on ordinary burnt clay ware (glazed pottery). An alkaline glaze was not employed on ordinary burnt clay ware because, as explained by Burton,[1] 'Such glazes are very uncertain in use, and can only be applied to pottery unusually rich in silica (i.e. deficient in clay). Consequently these alkaline glazes cannot be used on ordinary clay wares, and when they have been used successfully, the clay has always been coated with a surface layer of highly siliceous substance (e.g. the so-called Persian, Rhodian, Syrian, and Egyptian pottery of the early Middle Ages).' A lead glaze, on the other hand, is very satisfactory on ordinary burnt clay ware (pottery).

As to the date of the first use of a lead glaze on any base there is a considerable difference of opinion. Thus Burton states that 'The fact that glazes containing lead oxide would adhere to ordinary pottery when alkaline glazes would not was discovered at a very early period, for lead glazes were extensively used in Egypt and the nearer East in Ptolemaic times, and it is significant that, though the Romans made singularly little use of glazes of any kind, the pottery that succeeded theirs, either in western Europe or in the Byzantine empire, was generally covered with glazes rich in lead.'[1] Petrie[2] says: '. . . lead is essential with iron for the Ptolemaic apple-green.' Hobson

[1] *Ency. Brit.* 13th ed., v, Article *Ceramics*, p. 706.
[2] W. M. F. Petrie, *Ancient Egypt*, 1923, p. 23 (Review).

states[1] that 'Lead glaze has been freely used on late Roman pottery.' Dalton states that 'Pottery with a lead glaze is thought to have been first made in the first century B.C., when it appears on various sites at Alexandria, Tarsus in Asia Minor and in the Allier district of Gaul.'[2] Walters says: 'In the first century B.C. a new development may be observed in the introduction of a metallic, probably leaden, glaze used for coating clay objects in place of a slip or alkaline glaze.'[3] Harrison states that 'The first really satisfactory surface glass for use in pottery was what is called a lead glaze, known in Mesopotamia at any rate as early as 600 B.C.'[4] Sidney Smith illustrates 'Glazed ware of Babylonia and Assyria in the period 1000–600 B.C.,'[5] but neither the nature of the body material, nor of the glaze, is given.

Unfortunately, owing to the confusion created by the use of 'pottery' for faience[6] and also of 'faience' for pottery, it is sometimes impossible to know whether the material is really pottery or faience, as the case may be, especially for Islamic wares, since during the Arab period the two kinds of ware overlap one another. I have tested the glaze of a number of *faience* objects of different dates for lead, with the following results:

	Number tested	*Alk. Glaze*	*Lead Glaze*
IIIrd to XXIst Dynasties inclusive	8	8	0
XXIInd to XXXth Dynasties inclusive	4	1	3[a]
Ptolemaic and Roman periods	33	29	4[b]
Date unknown, but before Arab period	19	16	3[c]
Arab period	7[d]	4[e]	3[f]
	71	58	13

(*a*) One was a ram-headed bird amulet (Cairo Museum No. J. 56317) of XXIInd Dynasty date: another was a small statuette of a dwarf Ptah-Seker (Cairo Museum No. J. 54413) of the period XXIInd to XXVth Dynasties: a third was an inscribed vase (Cairo Museum No. J. 55621) of the Saite period. Two were green and one bluish-green.

[1] R. L. Hobson, *Guide to the Islamic Pottery of the Near East*, British Museum (1932), p. xv.

[2] O. M. Dalton, *Byzantine Art and Archaeology* (1911), p. 608.

[3] H. B. Walters, *Catalogue of Roman Pottery in the British Museum* (1908), p. xi.

[4] H. S. Harrison, *Pots and Pans*, pp. 52–3.

[5] Sidney Smith, *Early History of Assyria*, Pl. XV.

[6] The material described by Petrie as pottery (The Pottery Kilns at Memphis, pp. 34–7; Pls. XIII–XX, *Historical Studies*, II, 1911; *Memphis I*, pp. 14–5; Pls. XLIX–L) is probably largely, if not wholly, faience.

(*b*) One was dated by Mr. O. Guéraud to the 3rd cent. B.C. (F. W. von Bissing, *Fayencegefässe, Cat. Gén. du Musée du Caire*, No. 18026). The proportion of lead was small. The exact dates of the others are unknown; all were green.

(*c*) The glaze was green in two cases and blue in one case.

(*d*) For three of these specimens I am indebted to Hussein Effendi Rashed, Curator of the Museum of Arab Art, Cairo, who was good enough to date all seven specimens.

(*e*) One 13th cent. A.D.; one 14th cent. A.D.; two 14th–15th cents. A.D.

(*f*) Two 11th–12th cents. A.D.; one 14th–15th cents. A.D.

The thirteen specimens with a lead glaze, therefore, were faience, Variant F, the rest being ordinary faience; the one of the Twenty-second Dynasty (945–745 B.C.) is the earliest example of *faience* with a lead glaze known to me.

The test for lead was the ordinary one with potassium iodide, with which soluble lead compounds give a canary-yellow precipitate of lead iodide, the glaze being first treated with a drop of hydrofluoric acid. The technique of the test was that suggested by E. S. Hawkins and described and used by MacAlister,[1] who says: 'The test is extremely sensitive and beautiful and can be used on specimens without damage being done.'

C. Glazed Solid Quartz

The objects of glazed solid quartz were mostly small, such as amulets, beads, and pendants, though a few larger objects of this material are known, for example, part of a boat, which must have been about two feet long, but which was made in several sections, a sphinx, and part of a lion.[2] The quartz used was both quartz rock and rock crystal, and the glaze was an alkaline one. This material continued in use certainly as late as the Twelfth Dynasty.[3] Glazed quartz objects, some of them large, were found by Reisner in the Middle Kingdom Egyptian settlement at Kerma in the Sudan.[4] These the finder calls quartzite, but I have examined them in the Khartoum Museum and they are glazed quartz.

[1] D. A. MacAlister, *The Material of the English Frit Porcelain*: VI, *Lead Oxide as a Factor in Classification*, in *The Burlington Magazine* 54 (1929), pp. 192–9.

[2] W. M. F. Petrie, *Prehistoric Egypt*, pp. 42–3.

[3] W. M. F. Petrie, *loc. cit.*; see also H. C. Beck, *Notes on Glazed Stones*, Part II, *Glazed Quartz*, in *Ancient Egypt and the East*, 1935, pp. 19–30.

[4] G. A. Reisner, *Excavations at Kerma*, 1923, pp. 49–55.

D. Glazed Pottery[1]

The glaze from a number of specimens of Islamic pottery of Egyptian origin[2] was tested with the following results:

	Number tested	*Alk. Glaze*	*Lead Glaze*
Red pottery	15	0	15
Buff and light-brown pottery[a] . .	18	0	18
Very siliceous pottery[b] . . .	2	2[c]	0
	35	2	33

(*a*) Twelve are siliceous and several very siliceous.

(*b*) One reddish, one buff.

(*c*) In one of these specimens the glaze has almost entirely disappeared, and the adhesion, therefore, can never have been good. Both are 14th to 15th centuries A.D.

In connexion with glazed ware, glazed Greek pottery should be mentioned. Edgar says[3] of this pottery in the Cairo Museum that it includes objects acquired by purchase, as well as by excavation, and that 'most of the ordinary black-figured and red-figured vases are recent importations from Europe.' This type of pottery, however, was also 'manufactured in Egypt itself, many of the pieces . . . being products of a local fabric which flourished at Naukratis in the 6th century B.C.'[3] The black colour of the glaze of this pottery is attributed generally to ferrous silicate formed by the use of magnetic oxide of iron and an alkali.[4]

[1] Glazed pottery is only considered in connexion with the occasional late use on very siliceous pottery of an alkaline glaze similar to that employed for faience and the general use of a lead glaze. Lustre ware is intentionally omitted as being outside the scope of the present book.

[2] This pottery, which ranges in date from the 9th cent. A.D. to the 14th–15th cents. A.D., was kindly dated by Hussein Rashed, Curator of the Museum of Arab Art, Cairo, who supplied six of the specimens. For analyses of lead glaze see p. 551. Collie (J. N. Collie, *Trans. English Ceramic Society*, 15 (1915–16), p. 161) reports lead glaze on pottery of Eleventh Dynasty date, also lead glaze on a bead (material not stated) of the same date.

[3] C. C. Edgar, *Greek Vases*, pp. iii, iv.

[4] W. Foster, (*a*) The Composition of some Greek Vases, *Journal, American Chemical Society*, XXXII (1910), pp. 1259–64; (*b*) Chemistry and Grecian Archaeology, *Journal of Chemical Education*, 10 (1933), pp. 270–7; (*c*) L. Franchet, *Céramique primitive*, pp. 108–9; (*d*) W. B. Pollard, *Cairo Scientific Journal*, VI (1912), pp. 22–4.

Slip

A slip[1] on glazed pottery is a thin layer of a light-coloured clay sometimes applied to the body material before glazing in order either to mask the colour of the body, so that the glaze shall have its full colour effect, or to give a better adhesion to the glaze, in which latter case the slip is very siliceous. In part, and generally in large part, the function of the slip is analogous to that of the special layer applied to faience. A number of specimens of glazed pottery of the Arab period were examined for slip, with the following results:

	Number examined	*Slip*	*No Slip*
Red pottery	15	5	10
Buff and light-brown pottery .	20	0	20
	35	5	30

Origin of Glazing in Ancient Egypt

There can be little doubt that glaze was first produced by accident. A number of suggestions have been made to account for the discovery, three of which may be quoted. Petrie says[2] that it ' was invented from finding quartz pebbles fluxed by wood ashes in a hot fire,' which evidently means that glaze was produced accidentally on quartz pebbles by means of the alkali from the ashes of a wood fire, and that this glaze was copied intentionally. Another suggestion, probably also Petrie's,[3] is that ' it seems likely that glazing was developed in the course of copper smelting. The wood ashes of fuel would give the alkali, and lime and silica would be in the copper ore. Such a coloured slag or a glass run from it on to the pebble floor of the furnace, would then be the starting point for artificial imitations.' Elliot Smith suggests[4] that ' smelters who were extracting copper discovered in the slag of their furnaces the secret of how to make glazes for pottery. . . .'

All trees and plants contain mineral matter, which is left in the form of ashes when the material is burned, and all such ashes contain alkali. In the case of trees and most land plants, this alkali consists largely of potassium carbonate, the ashes of herbs and grasses generally being

[1] French *engobe*.
[2] W. M. F. Petrie, *Arts and Crafts of Ancient Egypt* (1910), p. 107.
[3] Anonymous review in *Ancient Egypt*, 1914, p. 188.
[4] G. Elliot Smith, *In the Beginning*, p. 58.

richer in this constituent than the ashes of trees and bushes. In the case of certain plants growing on or near the seashore, or near salt lakes, the alkali, instead of being largely potassium carbonate, is principally sodium carbonate. The alkali, whether potassium or sodium carbonate, is never pure, but is always associated with potassium or sodium chloride and sulphate and calcium carbonate, together with small proportions of phosphates, silicates, magnesium carbonate, and oxide of iron.

A number of experiments were made by me with two lots of ashes from different sources, obtained by burning ordinary garden refuse. A little of the ash was placed on each of a number of large flat quartz pebbles, which were then strongly heated for about an hour in a small electric muffle furnace giving a nominal temperature of about 1000° C. (1832° F.) and in some cases the pebbles were heated a second and even a third time, again for about an hour each time. Quartz sand was also covered with the ashes and strongly heated for about an hour. With one lot of ashes there was not any glaze whatever, either on the pebbles or on the sand, but with the other lot of ashes there were traces of a dark grey glaze on the pebbles, but none on the sand, the dark colour being due to particles of carbon from the ash having become entangled in the fused alkali. Although small variations in the results were obtained with plant ashes from two different sources, and therefore further slight variations might be expected with other ashes, it seems unlikely that any very marked glaze could be obtained in this manner, and still more unlikely that it could be obtained with the ashes from wood fires, since these, as already stated, contain less alkali than plant ashes. Even if it be assumed that fires were made continuously on the same spot for weeks, or months, or even years together—not entirely an unreasonable supposition in certain cases—any glaze formed would have been dark-coloured and neither very noticeable nor very attractive. The first hypothesis, therefore, fails when tested experimentally, and it fails doubly because it also does not explain the production of the blue colour of the earliest glaze, which is due to a copper compound.

The second hypothesis is equally unsatisfactory; it assumes that the floor of a primitive copper-smelting-furnace was accidentally covered with, or intentionally composed of, quartz pebbles, for which there is neither evidence nor probability, and also, either that copper slag may be blue, which it is not, or that a blue-coloured glass might run from it, which I believe to be impossible, since the amount of alkali present

from the ashes of the fuel would be quite inadequate, as is proved by the experiments already described. Also, as already shown, any glaze formed would have been a potash glaze and not a soda glaze, whereas the earliest glaze, so far as is known, is a soda glaze.

The third hypothesis is very vague, wholly unconvincing, and not supported by any evidence or experimental data.

Also none of the hypotheses explain the production of glazed powdered quartz (faience), or of glazed steatite, both of which, on present evidence, were earlier than glazed solid quartz.

Since, so far as is known, the earliest glaze was not a colourless one that later developed into blue, but was blue from the first, the problem to be solved is the manner in which an accidental blue glaze that was easily noticeable and sufficiently desirable to be copied, could have been produced.

As Hocart says with reference to glass: 'It is impossible to profit by a lucky accident unless the mind has been prepared by a long course of thinking and experimenting.'[1] The state of mind, however, that could have led to the copying of an accidental blue glaze probably existed, namely the desire to possess blue beads, beads in themselves being highly desirable, as they were supposed to possess amuletic or magical properties, and blue beads being particularly desirable, as their colour had a special value. Since the only Egyptian stones that could have been made into blue beads were turquoise, which was rare and expensive, and azurite, a blue ore of copper, which was also rare, not generally known, and not suited to carving, and since the imported lapis lazuli was also rare and costly, the only alternative was an artificial blue material; hence any blue glaze produced accidentally on a stone would, sooner or later, have been noticed and copied. The essential factors for the production of such a glaze were an alkali, copper or a copper compound, a stone to form a base for the glaze, and a fire. Since, as already shown, any glaze formed on quartz pebbles from the alkali in the ashes of a fire of wood or ordinary plants would have been negligible in amount, would not have been blue, and would have been a potash and not a soda glaze, this source of alkali may be ruled out. If so, then the alkali must have been either that from special plants growing on or near the sea-shore, or near a salt lake, or else natron.

The possibility of the use of plant ashes of a particular kind containing a high proportion of alkali in the form of sodium carbonate

[1] A. M. Hocart, *The Progress of Man*, p. 49.

cannot be ignored, since an ash containing sodium carbonate obtained from special plants grown in certain localities bordering the Mediterranean, chiefly Spain, but also Sicily, Sardinia, and the Levant, was formerly in general use for glass-making, the material from Spain being called *Barilla* and that from the Levant *Roquetta*, and such plant ashes were at one time produced in Egypt for this purpose. Thus in 1610 G. Sandys, when passing through the desert between Alexandria and Rosetta, saw[1] ' here and there a few unhusbanded Palmes, Capers, and a weed called Kall[2] by the Arabs. This they use for feuel and then collect the ashes which crusht together they sell in great quantity to the Venetians; who equally mixing the same with the stones that are brought them from Pavia, by the river of Ticinum, make thereof their crystalline glasses.' Ray in 1693[3] and Belon in 1553[4] say much the same.

Natron is a naturally occurring compound of sodium carbonate and sodium bicarbonate, which in Egypt always contains sodium chloride (common salt) and sodium sulphate as impurities; it is found plentifully in the country, chiefly in three localities, namely, the Wadi el Natrun, and the Beherah province in Lower Egypt, and El Kab in Upper Egypt, the first and third of these being known and worked anciently.

Since the earliest glaze was of Badarian date on steatite, the next in chronological order being of early predynastic date (S.D. 31) on powdered quartz, and the third, of middle predynastic date (S.D. 48) on solid quartz, and since the alkali must have been either from special plant ashes or from natron, the problem can be narrowed down to (*a*) the manner in which a blue glaze was formed accidentally at a period when copper smelting and copper working were in their infancy, but when malachite was well known and largely used as an eye-paint, and was therefore probably the source of the blue colour, and (*b*) to a district either on or near the sea-shore, or near a salt lake or natron deposit, or else to a place where special plant ashes or natron were being employed. Malachite, before being used as an eye-paint, was finely ground on hard stones, often quartz[5] or quartzite,[6] the grinding surface of which became coloured green in the process. In the presence

[1] *Sandys Travells* (1670), 6th ed., p. 90.

[2] Kali is probably meant.

[3] John Ray, *A Collection of Curious Travels and Voyages*, 1693.

[4] P. Belon, *Les Observations de plusiers singularitez et choses memorables, trouvées in Grece, Asie, Indée, Ègypte, Arabie et autres pays estranges, redigées en trois livres*, Mans, 1558 (original edition, 1553).

[5] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 112.

[6] G. Brunton, *Qau and Badari*, I, p. 62.

of a little alkali, and if strongly heated, such grinding-stones would have become coated with a blue glaze. This has been proved by a number of experiments, a little malachite being rubbed on quartz pebbles, then a little powdered natron put on, and the pebbles strongly heated, when they became coated with a good blue glaze every time. But what was the source of the alkali? It seems possible that the fused ashes of special plants, or natron, might have been employed for some such purpose as washing clothes or the person, and that this alkali might have been broken up for use on the same stones that had been employed for grinding malachite, and the stones afterwards strongly heated, for instance for putting into pots to boil water, or used to form a fireplace, or employed in some other manner in connexion with fire. In any case, whatever happened, it must have been something simple and something that occurred many times, since one occurrence would not have been enough for the glaze to be noticed and copied.

Method of Making Glaze

The essential ingredients of the ancient Egyptian blue glaze were an alkali, a very small proportion of a copper compound for colouring purposes, a little calcium carbonate (a trace of 'calcium' is given in a partial analysis of a predynastic glaze and 3.8 per cent of 'lime' in a glaze of Roman date; both of these being almost certainly present originally as calcium carbonate, which became converted into calcium silicate during heating), and a large proportion of silica. Since both powdered quartz and solid quartz are forms of silica, and since at a high temperature silica acts like an acid and attacks and combines with such substances as sodium carbonate, potassium carbonate, and calcium carbonate, it seemed likely that no further silica would be required. A little silica might also be present in the alkali, since plant ashes contain this ingredient, as do also the poorer qualities of natron; for example four specimens of natron analysed contained respectively 2.2 per cent, 6.7 per cent, 7.6 per cent,[1] and 9.6 per cent[2] of quartz sand. Also, since both plant ashes and natron contain a small proportion of calcium carbonate (the four specimens of natron already referred to containing 0.9 per cent, 1.3 per cent, 1.4 per cent, and 1.2 per cent respectively), and since even quartz contains a very small proportion (a white quartz pebble analysed containing 0.2 per cent), it was highly

[1] Contained also a little clay.
[2] Largely, but possibly not entirely, quartz sand.

probable that no additional calcium carbonate would be needed. Experiments, therefore, were made with only alkali and malachite, and it was found that by strongly heating either potassium carbonate (the principal constituent of wood and ordinary plant ashes) or powdered natron, mixed with a small proportion of finely powdered malachite, on quartz pebbles, a beautiful blue glaze was obtained every time. The reaction was not merely a fusing of the alkali and its coloration by means of the malachite, but the quartz was attacked by the alkali and, when the glaze was dissolved off, the surface of the pebbles was found to be much roughened underneath, the alkali having manifestly combined with some of the quartz, forming potassium or sodium silicate according to the nature of the alkali used. This has been noticed by Petrie, who says[1]: 'The fusion of the glaze on the stone partly dissolves the surface; and even after the glaze has been lost, its effect can be seen by the surface having the appearance of water-worn marble or sugar candy.'

In order to make quite sure that the addition of silica or calcium carbonate was not necessary, a number of experiments were made by adding various proportions of finely-powdered limestone to the alkali and malachite mixture, and other experiments were made with both finely-powdered limestone and finely-powdered quartz, but there did not appear to be any advantage, and there was a serious disadvantage in that the additions—as was only to be expected—made the fusion more difficult, with the result, either that no glaze whatever was formed, or that any glaze produced was poor.

Solid quartz having been successfully glazed, experiments were made with a view to glazing the powdered quartz base used for faience. This, however, was found to be more difficult, and when the alkali and malachite mixture was applied directly to the moulded material the glaze was never good and often very poor and sometimes there was none at all, the glazing mixture sinking into the quartz and colouring it blue. At first it was thought that the unsatisfactory results might be due to the heat employed having been too strong, or to the quartz not having been powdered finely enough, and so the experiments were repeated at a lower temperature and with a much finer and therefore denser quartz powder; but the results were only very slightly better. Eventually, however, a good glaze was obtained by first glazing solid quartz, then chipping off the glaze and powdering it finely, and finally

[1] W. M. F. Petrie, *Arts and Crafts of Ancient Egypt*, p. 107.

covering the moulded powdered-quartz object with the fine powder and heating. It is not suggested that this was precisely the method employed anciently, but it seems probable that the glaze mixture was first fused in some manner and then powdered and used. Thus in describing an imperfectly glazed object Quibell says: 'a patch . . . is covered, not with smooth glaze like the rest of the figure, but with minute grains of blue frit, this must be due to imperfect firing and shows that the glaze was applied as a wash of ground frit. The same method is seen in the ushabtis of a far later period.[1] Beck, as the result of his microscopical examination of Egyptian glazed objects, states that: 'All the specimens from Egypt, except a few which I believe to have been imported, appear to have had an already made glaze or else the ingredients to make a glaze powdered up and applied to the surface, and then to have been fused.'[2]

The modern method of glazing is first to make the glaze, when it not only looks like lumps of glass, but really is glass, though called 'frit,' next to powder it very finely and mix the powder with water to the consistency of thin mud, which is kept stirred to prevent the powder separating out, and then either to dip the objects in the 'mud' or to run the liquid 'mud' over the surface, the objects being afterwards dried and fired. A similar process on a small scale is used by several of the modern forgers of faience at Qurna. One particular forger seen by me buys small Venetian blue glass beads, powders them very finely, adds a little water, and to the 'mud' formed then adds rock salt, which is done by leaving lumps of rock salt to dissolve slowly. The object to be glazed is dipped in the 'mud,' dried and fired, the crystallization of the salt on drying and before firing aiding the adhesion of the powdered glaze until it is fired.

A few experiments were made with a view to glazing steatite, using the alkali and malachite mixture. Although the results were not very satisfactory, a glaze was obtained in several instances, though it was always green and not blue; whether this was due to the presence of iron compounds in the steatite, or to too high a temperature, was not determined.

It may be pointed out that whatever the precise details of the ancient method of glazing were, there can be little doubt that the firing was

[1] J. E. Quibell, *The Ramesseum*, p. 3.

[2] H. C. Beck, Notes on Glazed Stones, Part II, *Ancient Egypt and the East*, 1935, p. 21; H. C. Beck and J. F. S. Stone, Faience Beads of the British Bronze Age, *Archaeologia*, 1936, pp. 207–11.

carried out in a closed chamber of some sort, though probably only a small one, since it seems impossible that this should have been done in an open fire with the objects to be glazed in contact with the fuel. The modern forgers of faience at Qurna have evolved various ways of solving the difficulty: sometimes an earthenware pot is employed, sometimes a copper box, and sometimes a box of steatite, the objects in the latter case being stood on cubes of steatite.[1]

Binding Medium for Body

An important matter in connexion with faience is the manner in which the body material, which when dry has no coherence whatever, was held together while being shaped and glazed. That some binding substance was used in small amount seems incontrovertible. This is frequently stated to have been clay, though lime, silicate of soda, and organic materials, such as oil, fat, gum, or glue have all been suggested. These will now be considered, and it will be shown that some of them are impossible and others unlikely, and that the binding material employed was almost certainly an alkali (probably natron), or salt.

Clay

The microscopic examination does not show the presence of any extraneous or added material of any kind, and although the chemical analysis gives 1.3 per cent of alumina as the mean of four specimens, this, in the form of clay, would not be nearly sufficient to render the quartz powder plastic, and it is almost certainly merely an impurity present in the quartz, alkali or salt used, or picked up during the grinding or manipulation, as are also the oxide of iron, the lime, and the magnesia found on analysis. With respect to clay, Burton says[2]: 'After having tried many mixtures of the kind indicated by these analyses, I have been forced to the conclusion that the small amount of clay indicated by the percentage of alumina found would be entirely insufficient to give a material that could be shaped by pottery methods . . .' and of an Eighteenth Dynasty *shawabti*-figure he examined he says[3] that there was 'no trace of any clay substance.'

[1] Kindly communicated by Ahmed Fakhry, Chief Inspector, Department of Antiquities. The writer was shown only the copper box.

[2] W. Burton, *op. cit.*, p. 595. Mr. Burton was closely connected with the ceramic industry.

[3] W. Burton, *op. cit.*, p. 596.

Lime

The use of lime has been suggested by Beck, who says[1]: 'The core appears to be very nearly pure silica, has much the chemical composition of a silica brick, and is probably made in somewhat the same way. If powdered quartz crystals were mixed with about 2 per cent of lime and then heated in a furnace, a vitreous mixture would be formed which would cement the whole together, and it has been found in practice that this amount of lime, when added in the form of milk of lime, is sufficient to bind the dried material together before firing. . . . The analysis is practically the same as that given by Burton for Egyptian faience. I have examined some . . . sections of silica brick, and find that under certain conditions the quartz breaks and fuses in a manner extraordinarily similar to the faience. . . . One of the difficulties of this suggestion is that the lime and quartz would probably not fuse at a lower temperature than about 1,100° centigrade.' Beck also says: 'As the base of Egyptian faience consists of quartz grains fused together with a little lime . . .'[2]

In addition to the difficulty to which Beck draws attention, namely the very high temperature required to fuse a mixture of carbonate of lime and quartz, there are other difficulties; for example, in the case of sand-lime bricks it is slaked lime and not carbonate of lime that is used, and, as explained elsewhere,[3] there is no evidence that the Egyptians knew of lime before the Ptolemaic period; also when a sand-lime brick is examined it is seen that each grain of sand is surrounded by a thin film (probably consisting of silicate of lime), which is not the case with faience, the appearance of the two being totally different, and for the manufacture of sand-lime bricks a very considerable pressure (about 6 tons per square inch) is necessary for the moulding, after which a treatment with steam under pressure (120 to 200 pounds per square inch) in an autoclave is required, all of which would have been impossible in ancient Egypt.

A number of experiments were made by me, using both milk of lime (i.e. slaked lime and water) and powdered quicklime in varying proportions, ranging from 2 per cent to 50 per cent, the mixture being heated to the highest temperature available, about 1000° C. In no case

[1] H. C. Beck, Report on Qau and Badari Beads, in *Qau and Badari*, II (G. Brunton); also in Appendix I of *The Zimbabwe Culture* (G. Caton-Thompson). Mr. Beck informed me that carbonate of lime and not quicklime or slaked lime was meant.

[2] *Notes on Glazed Stones*, Part II, *Glazed Quartz*, p. 23. [3] See p. 93.

was there any cohesion or fusion, the mixture remaining in the original condition of a powder, though doubtless there would have been fusion at a still higher temperature.

Silicate of Soda

This is suggested by Sana Ullah of the Indian Archaeological Survey,[1] who says that 'possibly silicate of soda . . . was employed' for the flux. As will be shown, silicate of soda was the flux, but it was not used in that form, nor was it known to the ancients as a separate substance. The material employed was most probably natron or chloride of sodium (common salt), which produces silicate of sodium when heated with the quartz powder.

Organic Materials

With respect to the use of organic materials, such as oil, fat, gum, or glue, I thought at one time that there was possibly a small amount of evidence for their use, though this 'was too slight to be in any way conclusive.'[2] Thus in several instances, specimens of faience examined have shown a few small particles of black organic matter distributed throughout the mass that conceivably might have been the remains of some such adhesive, and in a large number of specimens from the Twenty-sixth Dynasty, constituting one lot of *shawabti* figures, the body material showed an inner grey-coloured core surrounded by a zone of white. Under the microscope the grey core was seen to contain numbers of black particles, which were probably charred organic matter, and, on being strongly heated, this core became definitely lighter-coloured, though not white. It was suggested, therefore, that some organic adhesive might have been used for binding the quartz together, and that the dark centre was due to this not having been completely burned away; but it is equally possible that the white outer layer was intentional and was the 'special' layer already described, put on in order to prevent the dark grey of the body from affecting the colour of the glaze, and that the grey may have been due to organic matter (accidentally present as an impurity, either in the quartz or in the natron) having been charred, but not burned out.

In order to test the value of organic materials as binders for quartz powder, a number of experiments were made with gum and oil, both

[1] In Sir John Marshall, *Mohenjo-daro and the Indus Civilization*, II, p. 687.
[2] See A. Lucas, *Ancient Egyptian Materials* (1926), pp. 34–5

of which formed with the quartz a paste that could be moulded and modelled. The objects made with gum could not be removed from the moulds either when dry, when they were firmly cemented in, or after firing, as they were then too friable, and if modelled and fired, the gum burned out leaving the objects so friable and fragile that it was impossible to handle them for glazing without breaking. The objects made with oil naturally did not dry, and therefore could not be removed from the moulds, and, whether moulded or modelled, after firing they were like those made with gum, so fragile that they could not be handled. Burton states[1]: 'I have with considerable difficulty succeeded in making a few small glazed figures by this method, they are softer and more rotten in body than any Egyptian glazed objects I have ever handled.'

Alkalies

The only alkalies known to the ancient Egyptians were (*a*) impure potassium or sodium carbonate in the form of plant ashes, and (*b*) sodium carbonate and bicarbonate in the form of natron; a simple addition of any of these would have been useless, as none of them is an adhesive. As, however, both potassium and sodium carbonate will combine chemically with quartz when strongly heated, forming potassium or sodium silicate, a large number of experiments were made with dry powdered natron and quartz powder, the latter obtained by grinding quartz pebbles very finely. The mixture was pressed with the fingers into small ancient faience moulds made of red pottery; these were heated in a small electric muffle furnace, the result being a coherent mass having varying degrees of hardness depending upon the proportion of natron present. With 2 per cent of natron the mass was so friable that it could not be removed from the mould without breaking; with 5 per cent of natron it approximated in friability to much of the ancient white faience body-substance[2]; with 10 per cent of natron it was slightly harder than ordinary faience, and with 20 per cent it was much harder. The experiments were repeated several times with substantially the same results. Natron, therefore, in the form of dry powder, added in the proportion of from about 5 per cent to about 10 per cent is a very effective binding agent, and may have been the one employed anciently.

[1] W. Burton, Ancient Egyptian Ceramics, *Journal, Royal Society of Arts*, 60 (1912), p. 599.

[2] C. G. Fink and A. K. Kopp, *Technical Studies*, 7 (1939), pp. 116–7.

But although dry natron might have been employed for objects that were moulded, it certainly could not have been used for objects that were shaped by hand. Experiments were, therefore, made with natron solution, and it was found that on account of the extreme fineness of the quartz powder any solution, even plain water, conferred on it a slight degree of plasticity, and that with a strong natron solution the plasticity was sufficient for the quartz to be made into a paste that with care might be fashioned into rough shapes, which, on partial drying, could be further shaped with a pointed instrument, and which when quite dry could be handled without damage and hence could be baked and glazed.

But it may be asked, if such a substantial proportion of natron as 5 or 10 per cent were used, why is it that it has hitherto escaped notice, and why is it not disclosed by chemical analysis? The reasons are briefly as follows: Natron consists essentially of sodium carbonate, sodium bicarbonate, and chemically combined water (water of crystallization), but it always contains both sodium chloride (common salt) and sodium sulphate and sometimes in considerable amount, the particular natron employed for many of the experiments containing 24 per cent of the former and 10 per cent of the latter. When natron is strongly heated with quartz, the sodium chloride largely disappears by volatilization; the sodium bicarbonate loses carbon dioxide and water and becomes converted into carbonate; the sodium carbonate (both that originally present and that formed from the bicarbonate) combines with some of the quartz, forming sodium silicate and carbon dioxide, which latter escapes, together with the water of crystallization and any moisture present. The total loss (sodium chloride; carbon dioxide; combined water and moisture, the escape of which would account for the air-holes in the finished product) would generally amount to more than 70 per cent of the weight of natron used; thus for every 10 grams of natron (supposing 10 per cent were used) not more than about 3 grams of material would be left combined with every 100 grams of quartz. Considering the very minute amount of the specimen taken for microscopical examination, it is no wonder that such a small proportion of sodium silicate (which is without colour or other conspicuous characteristic) should escape notice. In the chemical analysis the silica part of the sodium silicate, which is derived from and is identical with the quartz, cannot be separated or distinguished from it; it is, therefore, necessarily reported with it, and any small proportion of sodium found is reported as ' sodium oxide ' or ' alkali.'

The experiments referred to were made by me probably some time during 1931 or 1932, the results being communicated to and shown to friends at the time, but they were first published in 1933.[1] Subsequently I found that I had been forestalled some fifty years ago, when analyses were made in the Museum of Practical Geology, London, which showed that the white body of faience was 'composed of fine sand cemented by silicate of soda. The soda was probably introduced in the form of carbonate (derived, perhaps, from the Natron Lakes), and, having been mingled with the sand, the mixture was moulded, fired and glazed.'[2]

Salt (Sodium Chloride)

This, like natron, will act as a binder for the quartz powder, and it is used for this purpose by the modern forgers of faience at Qurna. That it is incorporated into the glazing mixture has already been mentioned, but it is also used with the body-material. As the result of a number of experiments, I have found that when salt is mixed dry with powdered quartz, put into moulds and strongly heated, the greater part of the salt disappears by volatilization, but sufficient combines with the quartz (forming sodium silicate) to bind it together. Also, when a strong solution of salt is mixed in the right proportion with powdered quartz, this can be shaped by hand or by simple pottery methods, and when dried, the crystallization of the salt by holding the quartz powder together imparts to it sufficient solidity to enable the mass to be handled for glazing. After firing at a high temperature no evidence of salt can be found on analysis.

[1] A. Lucas, *Ancient Egyptian Materials and Industries about 1350* B.C., in *The Analyst*, 1933, p. 657.

[2] Anon., *Handbook to the Collection of British Pottery in the Museum of Practical Geology*, London (1893), pp. 37–8.

CHAPTER X

GLASS

Although the chemical composition of ancient Egyptian glass is essentially the same as that of the ancient glaze, there is the difference between them that has already been mentioned, namely, the manner in which they were used, glaze always being applied to the surface of an object, whereas glass was employed independently, and, although with glass there was sometimes a temporary core, it was one to which the material was not intended to adhere and which was removed when the object was finished. This distinction is a most convenient one that should be maintained, as the use of glass on a large scale, as distinct from glaze, marks a definite epoch.

Origin and Date

In view of the very close connexion between glaze and glass, it seems highly probable that glass was not a separate discovery apart from glaze.

At what period glass objects were first made in Egypt is uncertain, but the regular production on a large scale dates from about the beginning of the Eighteenth Dynasty and by the middle of the dynasty the technique had reached a very high standard of excellence.

As the production of glass in Egypt before the Eighteenth Dynasty is of considerable importance in connexion with the history of the material, the evidence for this will be given.

The early glass objects are of two kinds, namely, (*a*) beads and tiny amulets, and (*b*) other objects, which will be considered separately.

Beads and Tiny Amulets

Predynastic Period. The examples known to me are (*a*) a glass bead found by Petrie at Nagada,[1] of which Beck says[2] 'From a

[1] (*a*) A. Scharff, *Die Altertümer der Vor- und Frühzeit Ägyptens*, Berlin, 1929, p. 108, No. 165, Tafel 25; (*b*) F. Rathgen, *Über Ton und Glas in alter und uralter Zeit*, Berlin, 1918, p. 18; (*c*) B. Neumann and G. Kotyga, Antike Gläser, ihre Zusammensetzung und Färbung, *Zeits. f. angewandte Chem.*, 38 (1925), p. 776.

[2] H. C. Beck, Glass before 1500 B.C., *Ancient Egypt and the East*, 1934, No. 2, p. 9.

photograph of the beads associated with it, I doubt its being as early as Predynastic. One of the other beads is evidently VIth. dynasty, or First Intermediate . . . I think this bead is also VIth. dynasty'; (*b*) a necklace of green, blue and yellow glass beads found by MacIver and Mace at Abydos.[1] Beck says[2] 'I hesitate to date them as Predynastic until further evidence can be brought forward to prove it.' I, also, hesitate to accept the predynastic dating, as, in my opinion, the presence of the yellow beads makes it improbable, since yellow as a colour for either faience or glass is not otherwise known until later.

Although, therefore, the dating of the beads claimed to be of the predynastic period needs confirmation before it can be accepted, yet, in view of the fact that glaze, which is glass applied to another material, is admittedly as early as predynastic times, it is not impossible, nor should it be a matter of surprise, if a few small objects, such as beads, proved to be of glass, since, if a little glaze had been dropped by accident on the ground, it might have been more or less spherical in shape, and, if bored, it would have become a glass bead.

Fifth Dynasty. Examples are beads and tiny amulets found by Schiaparelli at Gebelein and now in the Cairo Museum.[3] There are two strings of beads (a) and (b) and one string of beads and tiny amulets. String (a) consists of about 320 small black and small blue beads of opaque glass arranged alternately. There cannot be any doubt that these beads must be either glass or faience, and as I have ascertained that they have no core, therefore they are glass. But, whether they were intended for glass is another matter, since, as Reisner says[4] with respect to some very tiny ring-beads of faience from Kerma, 'owing to their small size the cores may have been more highly affected by the heat than in the larger beads and may have been fused with the glaze during firing.' Brunton gives a similar explanation for some beads he found,[5] an explanation that is so highly probable as to be almost certainly correct. String (b) consists of several hundreds of small bead-like objects, which are so dirty that their nature cannot easily be determined, and which cannot readily be cleaned, but almost certainly they consist entirely of thread wound into tiny balls. There are also about twenty tiny green amulets, several of which are broken, and, as there is no core, the material must be glass, though it may originally have been intended for faience.

[1] D. R. MacIver and A. C. Mace, *El Amrah and Abydos*, p. 54.
[2] H. C. Beck, *op. cit.*, No. 3, pp. 9–10. [3] Cairo Museum, No. J. 64816.
[4] G. Reisner, *Kerma*, pp. 91–2. [5] G. Brunton, *Qau and Badari*, I, p. 33.

Sixth Dynasty. Examples are (*a*) a bead examined by Beck, who says[1] ' There is no reason to doubt either the material, or date, of this specimen '; (*b*) about twenty-seven small glass beads, some blue, others dark green and others greenish found by Brunton and examined by me, the blue and dark green specimens being from Matmar.

Old Kingdom. Myers found glass beads probably of Old Kingdom date at Armant.[2]

First Intermediate Period. (*a*) Beck describes five glass beads, two green, one bluish, one of which the colour is not given, and one transparent red.[3] The finder, Brunton, suggests that the red bead may be a late intrusion; (*b*) more than seventy tiny blue amulets found by Brunton, who calls them ' openwork blue glaze with core dissolved in the glaze,' [3] which means that they are glass, although intended by the maker to be faience; (*c*) about 600 beads of various colours (blue, black, greenish) found by Brunton (some at Matmar) and examined by me. They have no core and, therefore, are glass.

Middle Kingdom. Examples are (*a*) the blue glass beads of Eleventh Dynasty date found by Winlock at Deir el Bahari[4]; (*b*) one blue glass bead of Twelfth Dynasty date identified by Beck[5]; (*c*) about six glass beads of Twelfth Dynasty date, of which the colour was not noted, and three others of the same date (opaque green with one end yellow) found by Brunton and examined by me.

Second Intermediate Period. About 550 glass beads of various colours (blue, black, red, green and yellow) found by Brunton and examined by me.

There is, therefore, no doubt whatever that glass beads and tiny glass amulets date from as early as about the Fifth Dynasty, and it is exceedingly probable that they were all of Egyptian manufacture and that they were the outcome of the use of glass as a glazing material for steatite and quartz (both solid and powdered). Some of these early beads, however, are not normal glass, but what elsewhere I have called ' imperfect glass,' [6] and what Reisner and Brunton call having the core fused, or dissolved in the glaze. They are not faience, which is glazed

[1] H. C. Beck, *op. cit.*, No. 22, p. 16.
[2] Sir R. Mond and O. H. Myers, *Cemeteries of Armant*, I, pp. 21, 72, 83.
[3] H. C. Beck, *op. cit.*, Nos. 12–15, p. 14.
[4] H. E. Winlock, *Bull. Met. Mus. of Art, New York, Egyptian Exped.*, 1921, p. 52.
[5] H. C. Beck, *op. cit.*, No. 22, p. 16.
[6] See p. 189.

quartz frit, since the material is of similar composition throughout without any coating of glaze, and, therefore, they must be classed as glass. This imperfect glass consists of a glass matrix in which a considerable proportion of uncombined quartz is embedded.

The colours of the earliest glass beads are black, blue and green. Yellow and red beads appear later.

Objects other than Beads and Tiny Amulets

These are (*a*) a Hathor head, which Petrie states[1] is predynastic and which he suggests is not Egyptian, but imported. Petrie, however, did not see this object in position as found, and, although he says that ' The grave is well dated by eight types of pottery,' possibly the object may have been found elsewhere and temporarily deposited by the workman who found it, for safety or for ease of transport (without any thought of deception), in the small vase in which Petrie first saw it; (*b*) a number of small pieces of inlay of First Dynasty date on part of a wooden box found by Amélineau at Abydos,[2] and now in the Ashmolean Museum at Oxford. The finder describes the material as ' émail,' which it is not. Beck states[3] that both ' Dr. Leeds and Mr. Harden have very carefully examined these specimens and are quite certain that they are faience and not glass.' Mr. Leeds kindly allowed me to examine this inlay, of which there are about ten pieces altogether, many black, or largely black with small green spots; one bluish-green and three green, one being very dark; all about one millimetre thick. In my opinion, the material is faience and not glass and it seems probable that the original colour was blue. Mr. Harden informed me that one piece that was taken out for further examination, the result of which had not then been received, had siliceous material at the back, which seems to prove that it is faience. In this connexion it may be pointed out that Petrie reports from the same place and of the same date ' A strange piece of inlay apparently green glass, partly decomposed with a dark strip let into it '[4]; (*c*) two uzat eyes of Tenth Dynasty date coloured black and white found by Brunton at Sedment,[5] of which there seems no reason to doubt either the material or the date; (*d*) an ' eye ' of transparent material and a fragment of yellow

[1] W. M. F. Petrie, *Prehistoric Egypt*, p. 43.
[2] Amélineau, *Les nouvelles fouilles d'Abydos, 1895–1896*, pp. 128, 306, Pl. XXXI.
[3] H. C. Beck, *op. cit.*, p. 10.
[4] W. M. F. Petrie, *The Royal Tombs*, I, p 38.
[5] W. M. F. Petrie and G. Brunton, *Sedment*, I, p. 6.

glass given to Parodi by Maspero, both from the tomb of Princess Khnumit at Dahshur. These were analysed by Parodi and stated by him to be glass.[1] The 'eye' is almost certainly the missing cornea from one of the eyes of the mask of Princess Knumit. There are in the Cairo Museum three pairs of eyes of Twelfth Dynasty date from Dahshur, all of which are alike, and from one of which the cornea is missing.[2] The other five corneas are all rock crystal and not glass, my identification being based both on the appearance of the material when examined with a lens, and also upon the fact that one of these corneas, which is loose, has been tested by me and will scratch glass. Parodi's analytical result, however, is certainly that of glass. The other specimen from this same tomb analysed by Parodi is stated to have consisted of two kinds of glass, one yellowish and the other *clair*, apparently only the former of which he analysed. That this fragment was indeed of Twelfth Dynasty date seems doubtful, since there is nothing else like it known of that date; (*e*) the well-known mosaic of Amenemmes III in black and white glass, now in the Berlin Museum, of which Newberry says[3] 'That this is contemporary with the king whose name it bears appears to me certain.' Von Bissing, however, thinks it is of Roman age.[4] I have examined this and it is certainly glass, but of what date I am unable to say. It should not be forgotten, however, that Amenemmes III was deified in the Graeco-Roman period, if not earlier, and objects may have been then made bearing his name. Although the beginning of glass mosaic is often attributed to the Roman period, it is at least several hundred years earlier, as is proved by the glass mosaic hieroglyphs on the coffin of Petosiris, which is dated to the early Ptolemaic period, and the glass mosaic figurines on a gilt mask of Ptolemaic date, both of which are in the Cairo Museum.[5] Also it should not be forgotten that the polychrome glass vases, some of which date back to the early part of the Eighteenth Dynasty, are really glass mosaics; (*f*) a blue glass vase of Seventeenth Dynasty date found by Brunton at Qau.[6]

[1] H. D. Parodi, *La verrerie en Égypte*, pp. 29–30. [2] See p. 126.

[3] P. E. Newberry, *Journal of Egyptian Archaeology*, VI (1920), p. 159.

[4] F. von Bissing, Sur l'histoire du verre en Égypte, *Revue archéologique*, XI (1908), p. 213.

[5] (*a*) A. Lucas, Glass Figures, *Annales du Service*, XXXIX (1939), pp. 227–35; (*b*) Ch. Picard, Les influences étrangères au tombeau de Petosiris: Grèce ou Perse?, *Bull. de l'inst. franç. d'arch. orientale*, XXX (1931), pp. 201–27; (*c*) G. Roeder, Die Baugeschichte des Grabes des Pet-Osiris, *Annales du Service*, XXXIX (1939), pp. 739–43.

[6] G. Brunton, *Qau and Badari*, III, p. 8.

But, in addition to the mistakes just mentioned, other mistakes in connexion with early glass have been made, for example, the greenish-blue material in the First Dynasty bracelets found by Petrie at Abydos and thought by Vernier to be glass[1] is not glass, but turquoise, as described by the finder, as is also the similar material in the Twelfth Dynasty jewellery from Dahshur, also queried by Vernier.[2] The medallion from Dahshur, which is a small pendant with the figure of an ox on a light blue ground, often described as a glass mosaic, is now known to be painted on a background of small blue particles embedded in a white matrix.[3] The cover is rock crystal and neither Iceland spar (*spath* as stated by the finder)[4] nor fluor spar as also suggested.

Most people are familiar with Pliny's story of the discovery of glass,[5] which is that a ship laden with natron (probably from Egypt) being moored at a certain spot on the shore of Phoenicia, 'the merchants, while preparing their repast upon the sea-shore, finding no stones at hand for supporting their cauldrons, employed for the purpose some lumps of natron which they had taken from the vessel' which the heat of the fire caused to combine with the sand and so produced glass. While this is certainly apocryphal, so far as the date and place are concerned, it is a perfectly feasible method of accidentally making a small quantity of glass and is by no means so fantastic as is often represented, those who criticize it adversely assuming wrongly that the sand must necessarily have been wholly siliceous and therefore that only sodium silicate, which is not glass, could possibly have been formed. But it is highly probable that the sand on the shore of Phoenicia was a quartz sand containing calcium carbonate, as is the case with much of the sand on the northern shore of Egypt, and such a sand, when fused with natron, will produce a soda-lime silicate, or true glass.

The remains of a number of glass works have been found in Egypt, the earliest being at Thebes and dating from the reign of Amenophis III[6, 7] (late Eighteenth Dynasty): three or four are at El

[1] E. Vernier, *Bijoux et orfèvreries*, pp. 10–1, 13–4.
[2] E. Vernier, pp. 88, 298, 299, 307, 336.
[3] A. Lucas and G. Brunton, The Medallion of Dahshûr, *Annales du Service*, XXXVI (1936), pp. 197–200.
[4] J. de Morgan, *Fouilles à Dahchour*, p. 67. [5] XXXVI: 65.
[6] P. E. Newberry, *op. cit.*, p. 156.
[7] A. M. Lythgoe, *Egypt. Exped. 1916–1917, Bull. Met. Mus. of Art, New York*, 1918, p. 6.

Amarna and belong to the reign of Akhenaton[1]: others of the Twentieth Dynasty are at Lisht[2, 3] and Menshiyeh respectively[2]: others again, of which the dates are not known, occur in the Wadi Natrun[4]; to the south and south-west of Lake Mareotis[4] and at Gurob[5] and one of Ptolemaic date is at Nebesheh.[6]

Alexandria was one of the greatest glass manufacturing centres of antiquity and Strabo (first century B.C. to first century A.D.) states[7] that he 'heard at Alexandria from the glass-workers that there is in Egypt a kind of vitrifiable earth without which expensive works in glass could not be executed . . .' In the literature of Roman times there are a number of references to Egyptian glass and under the emperor Aurelian there was a tax on glass imported into Rome from Egypt.

COMPOSITION

Ancient Egyptian glass is essentially a soda-lime silicate similar in the nature, though not in the proportions, of its constituents to a modern glass of ordinary quality, the latter of which however contains much more silica, a much smaller proportion of oxides of iron and aluminium, generally no oxide of manganese, much more lime, practically no magnesia and much less alkali.

The lower proportion of silica and lime, the greater proportion of oxide and iron and the considerably higher proportion of alkali in ancient Egyptian glass, as compared with modern glass, would all have acted in the way of materially lowering the temperature required for fusion, which was an important consideration and would have made the working of the glass easier, but at the same time the quality of the product would have been adversely affected, such glass being much less resistant to atmospheric influences that produce decay, especially damp. Another great difference between ancient and modern glass is that the latter, being largely employed to transmit light, is generally transparent, whereas the former, not having been needed for that purpose, but being mainly ornamental, though sometimes translucent and even occasionally transparent, was more generally opaque.

[1] W. M. F. Petrie, *Tell el Amarna*, p. 25.
[2] P. E. Newberry, *op. cit.*, p. 156.
[3] A. C. Mace, *The Murch Collection of Egyptian Antiquities*, in Supplement to *Bull. Met. Mus. of Art, New York*, 1911, p. 25.
[4] P. E. Newberry, *op. cit.*, p. 160. One of these has been seen by me.
[5] G. Brunton and R. Engelbach, *Gurob*, 1927, p. 3.
[6] F. Ll. Griffith, in *Nebesheh and Defenneh*, W. M. F. Petrie, p. 42.
[7] XVI: II, 25.

From the high proportion of oxides of iron and aluminium shown by the analyses and from the presence of oxide of manganese and of magnesia, the glass represented was manifestly not made from pure materials and the composition corresponds to what would be obtained by fusing together a mixture of sand and natron, neither of which are chemically pure substances, provided the sand contained, as it often does in Egypt, a certain proportion of calcium carbonate.

When yellow sand is used for glass making, the iron compounds present, to which the yellow colour is due, tend to produce a green colour in the glass, but in most ancient Egyptian glass, except the blue, this would not have greatly mattered and in some instances it is possible that the effects of the iron might have been neutralized by the oxide of manganese naturally present, which is a substance employed for this purpose in modern glass making. Quartz sand, however, containing only a small amount of iron and having very little colour occurs plentifully in Egypt and might have been used for special work.

It has been stated that glass was made at El Amarna from pure silica obtained by crushing quartz pebbles,[1] but this does not seem to agree with the original account as published,[2] according to which quartz pebbles were found only in connexion with the manufacture of blue frit, where freedom from iron is essential, and not for glass making, and the evidence from the analyses,[3] which cannot be ignored, points to the use of sand. If quartz pebbles, or other form of pure silica, had been used it would have been necessary to have added calcium carbonate (carbonate of lime) also, as lime is an essential constituent of the ancient glass, but with sand, the carbonate of lime would have been present as an impurity and its presence would not even have been known to the glass maker, who would merely have realized that in order to produce a satisfactory product a particular kind of sand was required.

From the analyses[3] it will be seen that the alkali is largely in the form of soda and that although potash is sometimes also present, it is generally only in very small proportion. This means that the alkali employed in the specimens analysed was natron, which consists of sodium carbonate and sodium bicarbonate, and not plant ashes, in which the alkali is chiefly potash. Browne, writing in 1799, says of glass

[1] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 124.

[2] W. M. F. Petrie, *Tell el Amarna*, pp. 25–7.

[3] See pp. 537, 539. See also M. Farnsworth and P. D. Ritchie, Spectrographic Studies on Ancient Glass, *Technical Studies*, VI (1938), pp. 169–73.

making in Egypt in his day 'Glass for lamps and phials is made at Alexandria, both green and white. They use natron in the manufacture instead of barilla: and the low beaches of the Egyptian coast afford plenty of excellent sand.'[1] Where only a trace of potash is present this probably occurred as an impurity in the natron, in which it is usually present in very small amount, but where there is a notable amount of potash this points to the use of plant ashes or to a mixture of these with natron.

The colour of ancient Egyptian glass may be amethyst, black, blue, green, red, white or yellow, and the nature of the various colouring matters may now be considered.

Amethyst Glass.

Two specimens of dark amethyst-coloured glass, both of the Twentieth Dynasty, analysed by me, were found to owe their colour to a manganese compound; Neumann and Kotyga[2] found this same colouring matter in a purple glass of the Eighteenth Dynasty and Farnsworth and Ritchie found a manganese compound (0.5 to 0.7 per cent calculated as oxide) in two specimens of Eighteenth Dynasty amethyst-coloured glass.[3] In this connexion it may be mentioned that white glass of ordinary quality containing manganese compounds becomes coloured if exposed to strong sunlight for some time.[4] The colour so produced varies from a very slight amethyst tint to a beautiful deep purple colour, and it is a matter of common observation in Egypt to find in the desert in the neighbourhood of towns, pieces of what have been white glass coloured in this manner. The coloration is due to manganese compounds in the glass having undergone some chemical change, which apparently is brought about by sunlight and is not caused either by heat or radio-activity, though the latter also produces a similar coloration. It is not, of course, suggested that the colour of ancient amethyst glass has been caused by exposure, or that it is other than original.

Black Glass.

I have been unable to obtain any specimen of ancient Egyptian black glass for analysis, nor does Parodi give any analyses of this glass, but

[1] W. G. Browne, *Travels in Africa, Egypt and Syria*, 1799, p. 10.
[2] B. Neumann and G. Kotyga, *Z. für angew. Chem.*, 38 (1925), p. 863.
[3] M. Farnsworth and P. D. Ritchie, *op. cit.*, pp. 167, 172.
[4] A. Lucas, *Effects of Exposure on Colourless Glass*, in *Cairo Scientific Journal*, XI (1922–3), pp. 72–3. J. Hoffmann, Photochemical Changes of Manganese Glass, *Chemical Abstracts*, 31 (1937), pp. 2293, 3649.

Neumann and Kotyga found that the colouring matter in two instances was due to copper and manganese compounds, and in a third case to a large proportion of an iron compound.[1]

Although black glass undoubtedly was made intentionally in Egypt at a late date, it is almost certain that the early black glass, such as that of the beads described elsewhere,[2] was due to the use of impure materials, containing, for instance, a large proportion of iron compounds.[3]

Blue Glass.

The ancient Egyptian blue glass is of three different shades of colour, namely, dark blue imitating lapis lazuli, light blue imitating turquoise, and greenish blue.

At the present day a cobalt compound is used for colouring blue glass, but as it only produces a dark blue colour, the turquoise blue and the greenish-blue of some of the Egyptian glass cannot ever be due to its use.

Until comparatively recently the usual test for cobalt compounds, which is both sensitive and characteristic, was by means of a borax bead in the flame of a Bunsen lamp or blowpipe, cobalt compounds colouring the bead a transparent, bright blue, both in the inner (reducing) and outer (oxidizing) flame, but since copper compounds also give a blue bead in the outer (oxidizing) though not in the inner (reducing) flame, there is some slight possibility of a mistake between the two. In many of the cases mentioned in which cobalt compounds have been reported, the nature of the test applied is not given, though it was certainly not spectroscopic, but in two of them (that of Mr. Pollard and one of those quoted by Lepsius) the borax bead test was relied on. In one specimen analysed by Clemm and Jehn, the cobalt was determined quantitatively and, in duplicate analyses, amounted to 2.86 and 2.82 per cent respectively expressed in terms of the oxide and in a specimen analysed by Clemm, also quantitatively, there was 0.95 per cent of cobalt oxide. Even though the determination of cobalt about sixty years ago may not have been quite as accurate as would be the case to-day, it is unlikely that the analyses should be wholly wrong. The most reliable test for cobalt, though it has only been used comparatively recently for this purpose, is by means of the spectroscope.

[1] B. Neumann and G. Kotyga, *op. cit.*, p. 864. [2] See p. 208.

[3] In this connexion see S. F. Nadel and C. G. Seligman, Glass-making in Nupe, *Man* (1940), 107, pp. 85–6.

Of the specimens analysed by me, three of the Eighteenth Dynasty and two of the Twentieth Dynasty all owed their colour to a copper compound: one specimen of dark blue glass from the tomb of Tut-ankhamun analysed by W. B. Pollard for me was found to be coloured by a cobalt compound[1]: a sample of blue Arab glass analysed for me by J. Clifford was free from cobalt and copper compounds, its colour being due to an iron compound, as was also the case with two specimens of blue glass of the Ptolemaic period analysed for me by H. E. Cox: Parodi found a copper compound as the colouring matter in one specimen of Egyptian blue glass of Persian times[2] and a cobalt compound in seven specimens, four of the Eighteenth Dynasty, two of the Twentieth Dynasty and one of the Persian period[2]: a cobalt compound was also found by Clemm and by Clemm and Jehn,[3] working in the laboratory of A. W. Hofmann (unfortunately the dates of the specimens are not given) and Lepsius, who quotes the analyses, mentions several other specimens in which a cobalt compound was present: Neumann and Kotyga did not find cobalt in any of the thirty-eight specimens of ancient Egyptian blue glass they examined and state that it was never used until Venetian times and that the colour is generally due to a copper compound, but occasionally to an iron compound.[4] Farnsworth and Ritchie[5] have recently examined sixty specimens of ancient Egyptian blue and blue-green glass (fifty-eight from the Eighteenth Dynasty and two from the period eighth to sixth century B.C.) spectroscopically with special reference to the presence or absence of cobalt, and they found that cobalt was present in thirty-five instances (58.3 per cent).

The finding of cobalt in Egyptian glass, especially at so early a date as the Eighteenth Dynasty, is of considerable importance, since cobalt compounds do not occur in Egypt except as traces in other minerals,[6] and their presence in the glass, if confirmed, would seem to indicate that the Egyptian glass makers of that time were in contact with glass makers elsewhere, who were using this material. Even in countries where cobalt ore occurs (for example Persia and the Caucasus region)

[1] A. Lucas, *Appendix*, II, p. 171, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

[2] H. D. Parodi, *op. cit.*, pp. 31, 33, 34, 38, 73.

[3] C. R. Lepsius, *Les métaux dans les inscriptions Égyptiennes*, trans. W. Berend, 1877, pp. 26–7.

[4] B. Neumann and G. Kotyga, *op. cit.*, pp. 862–3.

[5] M. Farnsworth and P. D. Ritchie, *op. cit.*, pp. 155–73.

[6] See p. 294.

its use at an early period is of interest, as the ore is not blue and, therefore, its value as a colouring agent is not naturally suggested, but in Egypt, where the ore is not found naturally, its use is still more interesting.

Green Glass.

A green colour in glass may be due either to compounds of copper or of iron, the colour of the modern green bottle-glass, for example, being produced by the latter. It is to a copper compound, however, that the green of the ancient Egyptian glass is due. One specimen of Eighteenth Dynasty date analysed by me was coloured by copper; also one of the Twentieth Dynasty examined by Parodi[1]; Neumann and Kotyga found copper compounds to be the colouring matter of all the specimens of Egyptian green glass examined by them[2] and Farnsworth and Ritchie found copper (and also lead) in a green glass of Eighteenth Dynasty date.[3]

Red Glass.

The colour of the Egyptian red glass is due to red oxide of copper. This is evident from the green coating that forms on the surface when the glass decays and is confirmed by analysis. Two specimens of this glass, one from the Eighteenth Dynasty and the other from the Nineteenth Dynasty, analysed by me were both found to owe their colour to a copper compound: the same result was found by Neumann and Kotyga,[4] and by Farnsworth and Ritchie.[3]

White Glass.

When glass is colourless and transparent or translucent it naturally does not contain any colouring matter, but when it is white and opaque this effect is generally produced by the addition of oxide of tin, which has been found in white opaque glass of the end of the Eighteenth Dynasty[5] and also of the Twentieth Dynasty and later.[5, 6] A specimen of tin oxide, almost certainly artificially prepared, was found in the tomb of Tut-ankhamun, which may possibly have been for use in making white opaque glass.

[1] H. D. Parodi, *op. cit.*, pp. 36, 69.
[2] B. Neumann and G. Kotyga, *op. cit.*, p. 858.
[3] M. Farnsworth and P. D. Ritchie, *op. cit.*, pp. 172–3.
[4] B. Neumann and G. Kotyga, *op. cit.*, p. 864.
[5] B. Neumann and G. Kotyga, *op. cit.*, p. 863.
[6] H. D. Parodi, *op. cit.*, pp. 34, 45, 73.

Yellow Glass.

A specimen of Egyptian yellow glass of the Nineteenth Dynasty was found by me to be coloured by a compound of antimony and lead and these same ingredients were found by Parodi in Egyptian yellow glass of both Persian and Arab times.[1] The specimen analysed by Neumann and Kotyga owed its colour to an iron compound.[2] Farnsworth and Ritchie give five analyses of yellow glass of Eighteenth Dynasty date, but refrain from giving a definite opinion as to the origin of the colour.[3] Lead occurs in all five specimens but antimony in only four.

Colourless, Transparent Glass.

When this was made first is uncertain, but from the Eighteenth Dynasty tomb of Tut-ankhamun there are a number of examples, for instance, on the back of the throne, on a pair of earrings, on parts of four geese on the middle coffin, and on a gold heart-amulet with a *benu*-bird, on all of which there are small painted designs covered with colourless, transparent glass. From the Nineteenth Dynasty there is part of a flail on the back of the figure of Anubis, and also the box or shrine on which the figure rests, which are painted and covered with colourless, transparent glass.[4, 5]

MANUFACTURE

As already stated, the ingredients for glass making, until a late date, were quartz sand, calcium carbonate, natron, or plant ashes, and a small amount of the colouring material. It seems almost certain that at first the calcium carbonate was not added as such and that its presence was unknown, but that it was used unconsciously as an admixture with the sand, it being recognized that, in order to obtain the required results, sand from certain localities only must be employed, such sand being quartz sand containing a natural admixture of calcium carbonate, which is fairly common in Egypt.

The ingredients were put into clay crucibles and strongly heated in a special furnace until complete fusion and combination between them had taken place and the main body of the resulting glass had become

[1] H. D. Parodi, *op. cit.*, pp. 36, 69.
[2] B. Neumann and G. Kotyga, *op. cit.*, pp. 863–4.
[3] M. Farnsworth and P. D. Ritchie, *op. cit.*, pp. 165, 166, 172.
[4] Cairo Museum, No. J. 31380.
[5] A. Lucas, Glass Figures, *Annales du Service*, XXXIX (1939), p. 234.

homogeneous and clear. The knowledge of when this end-point was reached would soon become a matter of practice with a skilled workman, but in some cases it was determined by taking out small quantities of the fused mass by means of pincers for examination.[1] When finished, the glass was poured into moulds, or poured out a little at a time and rolled into thin round rods, or the rods were flattened into strips, which were cut up into small pieces for inlay, or the glass was allowed to cool in the crucible, which was then broken away, as also the frothy upper surface (caused by the escape of carbon dioxide gas and combined water), and the dirty lower surface (due to impurities and dirt sinking to the bottom), and the glass was re-melted and used as required.

Petrie found evidence of small crucibles at El Amarna,[1] which were two to three inches both in depth and in diameter, but judging by the size of the glass vessels made, much larger crucibles sometimes must have been used, and in New York there is a mass of glass[2] of such a size that it must have been melted in a crucible with a capacity of more than 5,000 cubic centimetres. In most of the so-called glass works in Cairo, which are very small and very primitive, and in which glass is not made, but old bottles melted up and the material re-used, there are not any separate crucibles, the receptacles in which the glass is melted being built in as part of the furnace, there being generally three to each furnace, each of three workers having one in front of him. May not this custom have come down from earlier times? If so, separate crucibles, if used at all, may always have been small and only for special purposes.

Until a late period, beads were made singly by hand by winding thin glass threads round a copper wire and breaking off the thread after each bead.[3] During the Coptic period, a different method was employed, namely by drawing out a glass tube to the required diameter and then cutting it into beads.[3]

Vases were made on a sandy clay core, enclosed in cloth which was tied on with string, to which a rod of copper or wood was attached as a handle. This core was dipped into the molten glass and turned round quickly a few times in order to distribute the glass fairly evenly, though the vessels made are never very uniform in thickness. The core

[1] W. M. F. Petrie, (*a*) *Tell el Amarna*, pp. 26–7; (*b*) *The Arts and Crafts of Ancient Egypt*, pp. 120–5.

[2] The Metropolitan Museum of Art, New York, *Glass* (1936), p. 2., n. 1.

[3] See p. 59.

with the viscous glass on it cannot have been turned very much since the air bubbles usually are spherical and not elongated, as they would have been with much turning. If a pattern were required, this was made while the glass was still soft by winding round the outside thin rods of differently coloured glass, the very common wavy effect being produced by dragging the applied rods up and down. The whole was then rolled, probably on a stone slab, to produce a uniform and smooth surface. The rim, foot, and handle, if any, were added separately, and finally the rod was withdrawn and the core scraped out.

Small figures and certain other objects, such as the larger and more elaborate pieces of inlay, can have been made only by moulding[1, 2]: blown glass was not known until the Roman period—Harden says about the beginning of the Christian era.[2, 3]

Glass inlay is often called enamel, paste, or *pâte de verre*: it is certainly not enamel, which, although a vitreous material, is employed in the powdered state and fused into position by heat, whereas the ancient Egyptian material was always cut, or moulded, and cemented into position: the terms paste and *pâte de verre* are unsatisfactory, because meaningless, and they are often used very loosely and sometimes are even intended to be non-committal. The word paste, too, in connexion with glass has a very definite technical meaning and signifies the glass with a high refractive index and high lustre employed to imitate certain modern gems, particularly the diamond, and it cannot correctly be used to describe the soft glass without brilliance, or sparkle, made by the ancient Egyptians in imitation of precious or semi-precious stones. It is suggested, therefore, that the terms paste and *pâte de verre* should be discarded and that the material used should always be called what it is, namely, glass.

[1] Griffith found both limestone moulds and clay moulds for glass of Ptolemaic date. (F. Ll. Griffith, *Nebesheh and Defenneh*, W. M. F. Petrie, p. 42.)

[2] D. B. Harden, The Glass of the Greeks and Romans, *Greece and Rome*, III, pp. 140–9.

[3] P. Fossing, *Glass Vessels before Glass-blowing*, Copenhagen, 1940, pp. 5–23.

CHAPTER XI

METALS AND ALLOYS: MINERALS

The principal metals employed in ancient Egypt were copper, gold, iron, lead, silver and tin, but one instance of the use of antimony and one of platinum are known.

Three alloys were also employed, namely, bronze, which is essentially an alloy of copper and tin; electrum, an alloy of gold and silver; and, at a very late date, brass, which is an alloy of copper and zinc. In addition to these metals and alloys, a number of ores and natural mineral substances were also used.

These metals, alloys, ores and minerals will now be described.

Antimony

In view of the numerous erroneous statements that antimony was commonly employed in ancient Egypt, it becomes necessary to explain very clearly what antimony is. It is a bright, silver-white brittle metal, frequently having a crystalline structure, that is largely used at the present day for making certain alloys, such as type metals, Britannia metals and anti-friction metals. Although antimony occurs naturally in the free state as metal, this condition is extremely rare and it is generally found only in small amount, the antimony employed in industry being produced artificially from certain naturally-occurring compounds (ores). So far as is known, neither antimony nor antimony ores occur in Egypt, but probably traces of antimony compounds, though not recorded, are present in the local copper and lead ores and a trace has been found in the nickel ore from St. John's island in the Red Sea.[1]

Antimony ores are found in many parts of the world that have no connexion with ancient Egypt, but they also occur in countries that were in contact with Egypt, for instance they are plentiful in Asia Minor and occur also in Persia and, in small amount, in certain of the Greek islands (Mytilene and Chios).

Only one instance of the use of metallic antimony and very few

[1] F. W. Moon, *Prelim. Geol. Rpt. on Saint John's Island*, p. 16.

instances of the use of antimony compounds in ancient Egypt can be traced. The former consists of some small beads from the Twenty-second Dynasty (945 to 745 B.C.) found by Petrie at El-Lahun [1, 2] and, as the production of the metal from its ore at that date is most improbable, since the process was not known in Europe until about the fifteenth or sixteenth century A.D., it is almost certain that the beads were made from native metal, but whether this was brought to Egypt as metal or already fashioned into beads cannot, of course, be stated.

The only other instances of the use of metallic antimony in antiquity of which any record can be found, are two mentioned by Dr. Gladstone, who says,[2] 'M. Oppert indeed found at Khorsabad a tablet of metallic antimony and M. Sarzec found at Tello part of a vase of pure antimony.' The vase from Tello mentioned is the same as the 'Chaldean vase' referred to by Berthelot.[3, 4]

The instances of the use of antimony compounds in ancient Egypt that can be traced are (*a*) a Nineteenth Dynasty eye-paint consisting of antimony sulphide[5]; (*b*) an eye-paint (undated) which consisted of the sulphides of lead and antimony,[6] the relative proportions of the two not having been determined, though it is highly probable that the material was essentially galena (sulphide of lead) containing only a small proportion of sulphide of antimony as a natural impurity and (*c*) three other specimens of eye-paint, which contained traces of an antimony compound as an accidental impurity.[7] The general idea, therefore, that the ancient Egyptian eye-paint (other than the green malachite) consisted of, or contained, antimony or an antimony compound is wrong and there is no justification for calling it antimony, *stibium* (an early name for sulphide of antimony, transferred later to the metal), sulphide of antimony, or other name implying such composition. The misunderstanding has probably arisen from the fact that an antimony compound was employed as an eye medicine by the Greeks[8] and Romans.[9] The ancient Egyptian eye-paint, apart from the green malachite, consisted of

[1] W. M. F. Petrie, *Illahun, Kahun and Gurob*, p. 25; Pl. XXIX (56).

[2] J. H. Gladstone, *On Metallic Copper, Tin and Antimony from Ancient Egypt*, in *Proc. Bibl. Arch.*, XXIV (1891–2), pp. 223–7.

[3] *Comptes rendus*, CIV (1887), p. 265, quoted by H. C. and L. H. Hoover, in their translation of Agricola's *De re Metallica*, p. 429, *n.* 57.

[4] J. W. Mellor, *Inorganic and Theoretical Chemistry*, IX, p. 339.

[5] A. Wiedemann, *Varieties of Ancient Kohl*, in *Medum*, W. M. F. Petrie, p. 43.

[6] J. Barthoux, *Les fards, pommades et couleurs dans l'antiquité*, in *Congrès int. de géog., Le Caire, 1925*, IV (1926), p. 254.

[7] See p. 101.

[8] R. T. Gunther, *The Greek Herbal of Dioscorides*, V, 99.

[9] Pliny, XXXIII: 33, 34.

galena (sulphide of lead) sometimes containing traces of sulphide of antimony as a natural impurity, with such occasional substitutes as black oxide of copper, black oxide of iron and black oxide of manganese.[1]

In addition to the very rare use of an antimony compound as an eye-paint (possibly only one and at the most two examples being known), a compound of antimony and lead has been found as the colouring matter of yellow glass of the Nineteenth Dynasty, Persian period and Arab period respectively,[2] and traces of antimony occur in sundry ancient Egyptian copper and bronze objects, having been derived from an impurity in the copper ore.

In order, if possible, to prevent the perpetuation of mistakes and also to avoid being taken to task for ignoring several recently published statements asserting that antimony was used in ancient Egypt, I feel obliged, though very reluctantly, to explain why these instances are not included with those enumerated. Three of the most recent of such statements will, therefore, be discussed, namely:

1. Howard Carter, referring to certain dockets on the lids of three boxes from the tomb of Tut-ankhamun, says that these dockets, which give a list of the contents of the boxes (missing when the boxes were found), mention antimony among other objects and he adds, 'We found . . . antimony powder . . . dispersed on the floor of the chamber.'[3]

The inscriptions are in hieratic characters and only in two instances were they legible when found, and one inscription is now masked by the paraffin wax used to coat the box.[4] Of the two inscriptions left, one mentions only incense and gum (probably odoriferous gum-resin being meant) and the other refers to various articles, among which were two objects 'to serve for the putting on of *msdmt*,'[5] which is the word for eye-paint usually translated as antimony. I venture to say, however, that it does not mean antimony, and I doubt very much whether the Egyptians of that date (if ever) had a special word for metallic antimony, which until comparatively recently was a very rare metal, since its natural occurrence is so limited that it cannot have been well known until it was produced artificially from its ores, which was not earlier than about the fifteenth century A.D. But even if it be assumed that when *msdmt* is translated antimony it means, not metallic antimony, but an antimony compound, in view of what has been

[1] See p. 100. [2] See p. 219.

[3] Howard Carter, *The Tomb of Tut-ankh-Amen*, III, p. 119.

[4] This inscription could probably be rendered legible either by the removal of the wax, or by photography, using ultra-violet or infra-red rays.

[5] Kindly translated for me by Dr. J. Černý.

proved respecting the composition of the Egyptian eye-paints, it is equally improbable that it should have any such meaning.

The ' antimony powder ' stated to have been found in the tomb of Tut-ankhamun, if the expression be taken literally, means metallic antimony in a finely divided condition. But, considering the scarcity of metallic antimony anciently, the occurrence of such a material is so very improbable that nothing less than a chemical analysis would be sufficient to establish its identity and the bright, light grey, gritty material obtained by powdering metallic antimony would have been very unsuitable for use as an eye-paint. Even if the word antimony is used loosely to mean an antimony compound, such as the sulphide or oxide, which are the only two antimony compounds at all likely to have been known at the time, the appearance of these is so little characteristic that again a chemical analysis would be necessary for identification. It is suggested that a confusion has arisen between sulphide of lead (galena), the principal use of which in ancient Egypt was as an eye-paint (and small lumps of which were found in the tomb and are now in the Cairo Museum) and sulphide of antimony.[1] I would like to mention, too, that I had the privilege of working with Mr. Carter at Luxor during eight seasons and that I saw and handled most of the objects from the tomb and that, as a chemist, I am perfectly familiar with the appearance of metallic antimony and with the tests for antimony and antimony compounds and that nothing that was either one or the other came under my notice.

2. Gauthier, in a recent History of Egypt, says with reference to a scene in a tomb of Middle Kingdom date at Beni Hasan ' en particulier la poudre d' antimoine très recherchée par les Égyptiens . . . comme fard pour les yeux.' [2] Here it is not a matter of a material whose identity could be fixed by chemical analysis, but a question of translation, and all that has just been said on this subject is equally applicable in this case.

3. Fink and Kopp state that antimony plating was known in Egypt in about the Fifth or Sixth Dynasty.[3, 4] The evidence adduced consists

[1] Garstang (J. Garstang, *Burial Customs of Ancient Egypt*, p. 114) almost certainly makes a similar mistake when he says that ' fragments of antimony ore were found.'

[2] H. Gauthier, *L'Égypte pharaonique*, in *Précis de l'histoire d'Égypte*, I, p. 100.

[3] C. G. Fink and A. H. Kopp, *Ancient Egyptian Antimony Plating on Copper Objects*, in *Metropolitan Museum Studies*, IV (1933), pp. 163–7.

[4] C. G. Fink, *Chemistry and Art*, in (*a*) *Industrial and Engineering Chemistry*, 26 (1934), p. 236, and (*b*) *Chemistry and Industry*, 53 (1934), pp. 216–20.

of a copper ewer and basin of that date on the former of which are smooth bright areas of ' considerable size ' looking like silver and on the latter small scattered spots having the same silvery appearance, which when tested proved to be a thin layer of metallic antimony. The tests applied are given and there seems no doubt that the white metal is indeed antimony.

The possibility of the antimony having been derived from the copper is considered by Fink and Kopp and rejected, because (1) they were unable to find antimony in the copper; (2) they have never heard of a case of decuprification of the surface of a copper-antimony alloy and (3) a smooth bright deposit of antimony could never result from such a process. Hence they consider that the antimony plating was applied intentionally to simulate silver and two methods are suggested in which this might have been done, one using antimony sulphide and natron and the other oxide of antimony, 5 per cent acetic acid (equivalent to vinegar) and strips of iron, materials which it is stated ' are known to have been available in ancient Egypt.' These various arguments may now be considered.

1. That antimony was not found in the copper. Unfortunately neither the number of specimens of the copper tested, nor the method of testing are given. Naturally every possible care had to be taken to avoid disfiguring the objects and, therefore, large samples were impossible, but unless a number of samples were taken from different parts of the objects and unless these were tested by some very delicate method, such as the spectroscopic one, a small percentage of antimony might easily have been missed.

Antimony is not a very uncommon impurity in ancient Egyptian copper objects, and that it has not been found more frequently is probably largely owing to the fact that generally no search for it is made. However, it is recorded as present as a trace in a middle predynastic copper axe-head[1]; in two copper objects of the Fourth Dynasty[2]; in a copper object from the Twelfth Dynasty in which there was 0.2 per cent[3] and in another copper object, possibly from the same period, in which there was 0.7 per cent[4] and in a further,

[1] H. C. H. Carpenter, in *Nature*, 130 (1932), pp. 625–6.

[2] J. H. Gladstone, *On Metallic Copper, Tin and Antimony from Ancient Egypt*, in *Proc. Soc. Bibl. Arch.*, XIV (1892), pp. 223–7.

[3] J. H. Gladstone, *On Copper and Bronze of Ancient Egypt and Assyria*, in *Proc. Soc. Bibl. Arch.*, XII (1890), pp. 227–34.

[4] G. B. Phillips, *The Composition of some Ancient Bronzes*, in *Ancient Egypt*, 1924, p. 89.

undated but probably early, copper object in which there was a trace.[1]

2. That decuprification of the surface of a copper-antimony alloy is unlikely. If by this is meant the corroding away of the copper from the attacked surface of a copper object containing antimony, in such a manner as to leave the antimony, it is admitted that this is most improbable and that the antimony should be left as a thin, bright metallic layer is believed to be impossible.

That the ewer and basin had not only been corroded, but probably corroded to a considerable extent, is proved by the fact that they had been cleaned and that chemical, mechanical and electrolytic methods of cleaning had all been necessary. The effect of such corrosion must have been the destruction of the original surface, with the formation of the usual products found on corroded copper objects from Egypt, namely, chiefly copper oxide and basic carbonate, with some basic chloride, and, if it be assumed that the copper contained a small proportion of antimony as an impurity, which is neither impossible nor unlikely, this latter would probably have been converted into oxide. Then came the cleaning. This is stated to have been done by means of alternating baths of dilute alkaline and acid solutions, the loosened material being removed with wooden instruments or brushes, an electrolytic alkaline treatment being also mentioned. But, if the corroded surface contained oxide of antimony, as suggested, and if the electrolytic treatment was that advocated by Fink and Eldridge,[2] as appears very probable, then iron anodes would have been employed and all the conditions necessary to produce a thin coating of metallic antimony on the copper would have been present, and this antimony layer would have been deposited in much the same manner as is suggested by Fink and Kopp was done anciently (except that it would have been in an alkaline and not in an acid solution), namely by means of iron. The improbability that the ancient Egyptians at any period, particularly at so early a date as that of the ewer and basin, knew antimony plating is so great that very much stronger evidence than that cited is necessary before it can be accepted as a proved fact, and I suggest that the patches and spots of plating found may have been the result of the process of cleaning employed, and that they were brought

[1] M. Berthelot, in *Recherches sur les origines de l'Égypte*, J. de Morgan, I, pp. 223–9.

[2] C. G. Fink and C. H. Eldridge, *The Restoration of Ancient Bronzes and other Alloys*, pp. 15–7.

about by the reduction of oxide of antimony (or other antimony compound present in the corroded surface of the copper) to the metallic state.[1]

Fink and Kopp state that 'Antimony sulphide has been found in ancient specimens of Kohl . . . and antimony oxide is readily derived therefrom by roasting.' So far as is known, only one specimen of *ḳohl* (and that of a date from 1,100 to 1,500 years after that of the ewer and basin) has been found that consisted of sulphide of antimony; one other specimen may have contained a substantial proportion of sulphide of antimony, but it is more probable that it contained only a very small amount, and a few others contained traces. But, even if a few specimens of *ḳohl* of the necessary date did consist of sulphide of antimony (which is not probable and for which there is no proof), it would require considerable evidence to establish as a fact that some of this *ḳohl* was converted into oxide of antimony by roasting and that the oxide so obtained was then employed for plating a ewer and basin. It is most improbable, too, that strips of iron should have been employed in the Fifth or Sixth Dynasty. Even if iron were generally known, which was not the case, that it should have been used in the manner suggested is very unlikely.

Copper, Bronze and Brass

Copper

Copper, which, unlike gold, is not usually found in nature in the metallic condition, but which generally must be produced artificially from unattractive-looking ores, was yet one of the earliest metals known to man. In Egypt it was employed before gold as far back as Badarian and early predynastic times.

The earliest copper objects found are beads, borers and pins, which date from the Badarian period[2] and which continued in use during the early predynastic period, supplemented however by bracelets, small chisels, finger rings, harpoon heads, small implements, needles,

[1] The usual form of plating known to the ancient Egyptians was that of hammering thin sheets of one metal on to another. See gold plating (p. 265) and silver plating (p. 284).

[2] G. Brunton and G. Caton-Thompson, *The Badarian Civilization*, pp. 7, 27, 33, 41.

tweezers and other small articles.[1-7] 'All the objects previous to the middle predynastic are rare, small and flimsy,'[8, 9] but, by the end of the predynastic period, the Egyptians 'were in possession of practical copper weapons'[8] and during the early dynastic period 'heavy practical axe-heads, adzes, chisels, knives, daggers, spears, implements and ornaments'[8] as well as household utensils, such as ewers and basins, were in use in considerable numbers. The number of worked copper objects of First Dynasty date found by Petrie in the royal tombs or cenotaphs at Abydos was considerable, although these had been robbed and also excavated previously, and recently Emery has found a very large number of copper objects in the First Dynasty tomb of Zer at Saqqara, which included 121 knives, 7 saws, 68 vessels, 32 bodkins, 262 needles, 15 piercers, 79 chisels, 75 rectangular plates, 102 adzes and 75 hoes.[10]

It is sometimes stated that during the earlier periods when copper was used in comparatively small amount, it was obtained from native metal (i.e. copper found naturally in the metallic state), but however this may be, which will be discussed later, there cannot be any doubt that in all subsequent periods it was derived entirely from the smelting of ores. A copper chisel of early dynastic date, analysed by Professor C. O. Bannister and quoted by Professor C. H. Desch, contained 2.51 per cent of silver and 4.14 per cent of gold, of which Desch says,[11] 'The composition of this specimen, with the high proportion of silver and gold, suggests that it is composed of native metal.'

[1] G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 56, 60, 71.
[2] E. R. Ayrton and W. L. S. Loat, *Predynastic Cemetery at El Mahasna*, pp. 18, 19, 21, 32, 33.
[3] W. M. F. Petrie, *Diospolis Parva*, p. 24.
[4] D. Randall-MacIver and A. C. Mace, *El Amrah and Abydos*, pp. 16, 18, 20, 21, 23, 24.
[5] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 14, 20–4, 27–9, 45, 47, 48, 54.
[6] W. M. F. Petrie, *Prehistoric Egypt*, pp. 25, 26, 47.
[7] W. M. F. Petrie, *Tools and Weapons*.
[8] G. A. Reisner, *Early Dynastic Cemeteries of Nag-ed-Der*, I, pp. 127, 128, 134.
[9] Brunton found a large copper axe-head weighing three and a half pounds of the middle predynastic period (H. C. H. Carpenter, in *Nature*, 130 (1932), pp. 625–6).
[10] W. B. Emery, A Preliminary Report on the First Dynasty Copper Treasure from North Saqqara, *Annales du Service*, xxxix (1939), pp. 427–37.
[11] C. H. Desch, *Report on the Metallurgical Examination of Specimens for the Sumerian Committee of the British Association*, in *Report of the British Association*, 1928.

Coghlan also says[1] that a large percentage of gold and silver would indicate a native origin for the metal. The chisel analysed by Bannister was supplied by me, and was received from the late Mr. C. M. Firth, who found it in Nubia. It is most unlikely that such a comparatively large object as the chisel in question and of the period to which it is dated should have been made out of native copper, and a very much more probable explanation is that the copper ore used had contained small proportions of gold and silver,[2] a phenomenon not unknown in the eastern desert, whence the copper ore was probably derived. Thus Ball states[3] that in the south-eastern desert ' Besides gold some of the quartz veins contain copper,' and the Dungash gold mine (situated east of Edfu) also contains veins of copper ore.[4]

Rickard says[5] that ' native copper is far more abundantly distributed than is generally supposed ' and that ' The use of native copper marks the beginning of every ancient metal culture.' That copper is found native in various parts of the world and that in certain localities, especially in North America, it occurs in abundance and that at one time this copper was used largely for making ornaments, weapons and tools, is well known, but the people who employed it never on their own initiative got beyond its use and never proceeded to the smelting of copper ores. That native copper was ever found and used in Egypt lacks proof, and though some few of the earliest copper objects, the Badarian beads for example, *may* have been made from native copper, that they were so made is by no means certain, and such statements as the following go beyond the proved facts: ' The predynastic graves of Egypt . . . contain beads of native copper . . .'[6]; ' in the Badarian graves of the Fayum there is native copper . . .'[7]; ' Traces of copper, chiefly pins, needles and bodkins hammered out of native metal are found in the debris of the earliest agricultural settlements of the Nile Valley '[8]; and ' It is now generally accepted that the first metal to be found on all prehistoric copper sites, at the earliest time, is native copper.' [9]

[1] H. H. Coghlan, Some Fresh Aspects of the Prehistoric Metallurgy of Copper, *The Antiquaries Journal*, XXII (1942), p. 24.

[2] All Egyptian gold contains silver.

[3] J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, p. 353.

[4] See p. 235. [5] T. A. Rickard, *Man and Metals*, I, pp. 105, 106, 108.

[6] T. A. Rickard, *op. cit.*, I, p. 96.

[7] T. A. Rickard, *The Early Use of the Metals*, in *Journal Inst. Metals*, XLIII (1930), p. 305.

[8] E. A. Marples, *The Copper Axe*, in *Ancient Egypt*, 1929, p. 97.

[9] H. H. Coghlan, *op. cit.*, p. 22.

In any discussion of the question whether or not native copper was employed in Egypt there is one very important fact to be taken into account, namely, the use as eye-paint of considerable quantities of an ore of copper (malachite) that occurs in the country; that is easily converted into copper; that can be proved to have been employed later as a source of copper, and the use of which can be traced as far back as the use of copper and possibly even farther and, therefore, the conditions in Egypt were particularly favourable for the early discovery of copper by smelting the ore, and there is no need to postulate the occurrence and use of the native metal.

Copper ores occur within the geographical limits of modern Egypt in two widely separated localities, namely, in Sinai and in the eastern desert. The amount of ore, however, is not sufficiently large to warrant mining at the present day, since copper ores may be obtained in much greater quantity and in more easily accessible places elsewhere.

The evidence for ancient copper mining and smelting by the Egyptians is twofold, first, the existence of ancient mines with ruins of mining settlements and ancient slag heaps, and second, inscriptions in the neighbourhood of mines left by mining expeditions.

Sinai

Ancient workings, some of which are of considerable size, which admittedly were either for copper ore or for turquoise, exist at Magharah and at Serabit el Khadim, both of which are situated in the south-west of the peninsula of Sinai and about twelve miles apart.[1-5]

That some of these workings were not for copper ore, but for turquoise (which was employed for beads and jewellery in both the Old and Middle Kingdoms and even as early as the Badarian period),[6] there can be no doubt, since at both places turquoise is still found and at Magharah turquoise mining is carried on by the local bedouin at the present day, the main workings extending for about two

[1] J. de Morgan, *Recherches sur les origines de l'Égypte*, pp. 216–39.
[2] W. M. F. Petrie, *Researches in Sinai*, pp. 18, 19, 27, 46–53, 154–62.
[3] J. Ball, *The Geog. and Geol. of West-Central Sinai*, pp. 11, 13, 163, 188, 190, 191.
[4] T. Barron, *The Topog. and Geol. of the Pen. of Sinai (Western Portion)*, pp. 40–5, 166–9, 206–12.
[5] Mines and Quarries Department, Egypt, *Report on the Mineral Industry of Egypt*, 1922, pp. 36, 38.
[6] See p. 240, n. 3, and also p. 460.

kilometres on the west side of the valley.[1, 2, 3] At Serabit el Khadim, although turquoise occurs, it is only found at the present time in small quantity and is not now worked.[1–4]

In addition to turquoise, however, copper ore also undoubtedly was mined anciently at Magharah, since ruins of mining settlements exist, dating principally from the Old Kingdom, but also from the Middle Kingdom, in the former of which have been found 'a great amount of copper slag and waste scraps from smelting; also some chips of copper ore, many broken crucibles and part of a mould for an ingot,'[5] and in the latter 'a great quantity of copper slag, scraps from smelting, pieces of crucibles, charcoal and, in one case, part of a crucible-charge of crushed ore not yet reduced,'[6] also a mould (undated) for casting the blades of weapons.[7]

At Serabit el Khadim the proof of ancient copper mining is less evident, as the workings have not been examined carefully from this point of view, but copper ore occurs in the immediate neighbourhood and a crucible for melting copper was found in the temple.[8] Starr and Butin state that 'The amount of mining carried out at Serabit in antiquity was immense' and 'There is no evidence whatsoever that the Egyptians sought at Serabit anything other than turquoise.'[9]

The copper ore mined anciently, both at Magharah and at Serabit el Khadim, was largely the green carbonate (malachite), with a little blue carbonate (azurite) and a little silicate (chrysocolla), only small quantities of any of which now remain.[10, 11, 12]

The inscriptions left by the mining expeditions were[13] at Magharah; in the valley and mines near Serabit el Khadim; in the temple at Serabit el Khadim and the approach to it and in the Wadi Nasb.[14, 15]

[1] Petrie, *ibid.*
[2] T. Barron, *ibid.*
[3] Mines and Quarries Dept., *ibid.*
[4] J. Ball, *ibid.*
[5] W. M. F. Petrie, *op. cit.*, p. 51.
[6] W. M. F. Petrie, *op. cit.*, p. 52.
[7] J. de Morgan, *op. cit.*, I, p. 229.
[8] W. M. F. Petrie, *op. cit.*, p. 162.
[9] R. F. S. Starr and R. F. Butin, *Excavations and Protosinaitic Inscriptions at Serabit el Khadem*, 1936, p. 20.
[10] J. de Morgan, *op. cit.*, pp. 216–39.
[11] J. Ball, *op. cit.*, pp. 188, 191.
[12] T. Barron, *op. cit.*, pp. 166, 208.
[13] The word is employed in the past tense as many of the inscriptions have either been destroyed or removed.
[14] J. H. Breasted, *Ancient Records of Egypt*, v (Index), pp. 95, 102.
[15] A. H. Gardiner and T. E. Peet, *The Inscriptions of Sinai*, I, pp. 7–16.

At Magharah there were[1] 45 records, consisting of 36 inscriptions on the rocks, 8 graffiti and one stela, which began in the First Dynasty (1 inscription) and were continued in the Third Dynasty (3 inscriptions); Fourth Dynasty (3 inscriptions); Fifth Dynasty (8 inscriptions); Sixth Dynasty (2 inscriptions); Twelfth Dynasty (13 inscriptions); Eighteenth Dynasty (1 inscription) and Nineteenth Dynasty (1 inscription), with also 5 inscriptions of the Old Kingdom and 8 of the Middle Kingdom that cannot be assigned to any particular dynasty.

In the valley and mines near Serabit el Khadim there were[1] 15 records (10 from mines and one possibly from a mine) consisting of 13 inscriptions on the rocks and 2 stelae. They were of the Twelfth Dynasty (10 inscriptions) and Eighteenth Dynasty (3 inscriptions) with one of the Middle Kingdom of which the dynasty cannot be recognized and one of doubtful date.

In the temple and its approach there were[1] 288 inscriptions, principally on loose blocks of stone, statuettes, free-standing stelae and other objects, but including a number of inscriptions on walls and pillars. These consisted of one inscription with the name of Sneferu (which is almost certainly of later date than the reign of this Pharaoh and probably not earlier than the Middle Kingdom) together with the following named: Twelfth Dynasty (72 inscriptions); Eighteenth Dynasty (75 certain inscriptions and 11 less certain); Nineteenth Dynasty (30 inscriptions); and Twentieth Dynasty (22 inscriptions); also 38 certain inscriptions and 4 less certain of the Middle Kingdom; 18 certain inscriptions and 2 less certain of the Nineteenth to Twentieth Dynasties and 15 inscriptions of which the dates were altogether doubtful.

In the Wadi Nasb there was one inscription on the rock of the Twelfth Dynasty.

The inscriptions in those instances where there was any reference to the nature of the activities undertaken, frequently made mention of turquoise[2] and once of copper, but they were very unsatisfactory for use as a history of Egyptian copper mining. Thus the earlier ones (First, Third, Fourth and beginning of Fifth Dynasties respectively) merely recorded the names and titles of the Pharaohs, then reference to the leaders and officers of the expeditions were included (Fifth Dynasty) and at later dates statements of the objects of the expeditions.

[1] The word is employed in the past tense as many of the inscriptions have either been destroyed or removed.

[2] The word used is *mafkat*, which Breasted translates as malachite; see p. 461.

Although there can be little doubt that all the expeditions were for the purpose of mining either copper ore or turquoise, there is no direct proof of this from the inscriptions themselves in the case of the earlier ones, which might have been merely punitive expeditions, though they are believed to have been more.

In addition to the workings at Magharah and at Serabit el Khadim, already mentioned, ancient workings for copper ore exist at the following-named places in the neighbourhood of Serabit el Khadim:

1. Gebel (mount) Um Rinna, situated N.N.W. of Serabit el Khadim, where there is an excavation some 20 metres wide, one to two metres high and about 50 metres long. The ore extracted was malachite, traces of which still remain.[1]

2. Wadi (valley) Malha. These workings are close to Gebel Um Rinna, Wadi Malha draining the eastern flank of the mountain. The ore mined was malachite, small quantities of which still exist.[2]

3. Wadi (valley) Kharig, called Wadi Halliq by Barron. This is situated to the west of the northern portion of Wadi Nasb. Here there is an excavation about 100 metres long, 10 metres wide and two metres in average height. The ore extracted was malachite, which practically has been exhausted.[3, 4]

In the south-east of the peninsula ancient workings for copper ore and ancient slag heaps exist in several places, namely:

1. Near the plain of Senned. The working here is in the nature of a dyke, which has been excavated for nearly two miles and is 'exceedingly rich' in the blue carbonate (azurite).[5]

2. In the hills west of the Nebk-Sherm plain. Some of the ore is malachite, and possibly this alone was worked anciently, but chrysocolla also exists, a deposit having been found by modern prospectors at Wadi Samra (sometimes called Wadi Samara).[5]

3. Near Wadi Ramthi, one of the feeders of Wadi Nasb, which enters the Gulf of Aqaba at Dahab.[6]

In addition to the slag heaps situated at some of the mines, which have already been mentioned, there are also a number of others where there are not any mines, the largest of which is in Wadi Nasb (called Wadi Nasib by Ball), which is situated north-west of Serabit el

[1] J. Ball, *op. cit.*, p. 188.
[2] T. Barron, *op. cit.*, p. 166.
[3] T. Barron, *op. cit.*, pp. 167, 206.
[4] J. Ball, *op. cit.*, pp. 190, 191.
[5] W. F. Hume, *The Topog. and Geol. of the Pen. of Sinai (South-Eastern Portion)*, pp. 118, 119.
[6] Kindly communicated by Dr. Ball.

Khadim. In this wadi, as already stated, there is an inscription of the Twelfth Dynasty. In continuation of this heap there is much scattered slag all the way up the path to the stela of Amenemmes IV.[1-4]

Similar, but smaller, ancient slag heaps exist at the south side of Seh Baba (the lower part of Wadi Nasb), which is situated to the south-west of Serabit el Khadim.[5]

Another ancient slag heap is at Gebel (mount) Safariat south of Gebel Hebran.[6]

Eastern Desert

Copper ore exists in a number of localities in the eastern desert, namely:

1. In Wadi (valley) Araba, which is situated almost due east of Beni Suef (about Lat. 29° N.), near the Gulf of Suez. A specimen of ore examined by me was chrysocolla: the amount of ore is only small and there is no evidence that it was mined anciently.[7]

2. At Gebel (mount) Atawi, which is situated a little south of the latitude of Luxor, but nearer the Red Sea than the Nile. There are ancient workings, but the nature of the ore is not stated.[7]

3. At Gebel (mount) Dara (approx. Lat. 28° N.; Long. 33° E.), where there are ancient workings. The ore is chrysocolla.[7, 8, 9]

4. In the Dungash gold mine, which is situated east of Edfu (approx. Lat. 24° 50′ N.; Long. 33° 45′ E.). The nature of the ore is not stated, nor whether it was worked anciently: the amount of ore is probably very small.[7]

5. Among the low hills south of Wadi (valley) Gemal (Lat. 24° 35′ N.; Long. 34° 50′ E.). The ore is malachite, but it is not stated whether there are ancient workings.[7, 10]

6. At Hamish (Lat. 24° 32′ N.; Long. slightly E. of 34°). There are old workings with three main shafts. The ore is chalcopyrite (sulphides

[1] W. M. F. Petrie, *Researches in Sinai*, p. 27.
[2] J. Ball, *op. cit.*, p. 13.
[3] T. Barron, *op. cit.*, pp. 44, 208.
[4] T. A. Rickard, *Man and Metals*, 1, pp. 196–7.
[5] W. M. F. Petrie, *op. cit.*, pp. 18–9.
[6] T. Barron, *op. cit.*, p. 208.
[7] W. F. Hume, *Explan. Notes to Geol. Map of Egypt*, p. 37.
[8] T. Barron and W. F. Hume, *Top. and Geol. of the Eastern Desert of Egypt, Central Portion*, pp. 33, 259.
[9] J. Wells, *Report of the Dept. of Mines*, 1906, p. 34.
[10] W. F. Hume, *A Prelim. Report on the Geol. of the Eastern Desert of Egypt*, pp. 41, 56.

of copper and iron). The sides of one shaft are encrusted with blue copper compounds formed from the pyrites.[1]

7. At Abu Seyal (sometimes wrongly called Absciel) in Lat. 22° 47′ N. Wells reported that the ore occurred in the form of pyrrhotite (iron pyrites) associated with copper pyrites (copper sulphide),[2] but, although there may be copper pyrites at some distance below the surface, the ore exposed is chrysocolla. The mine was worked extensively in ancient times and some at least of the ore was smelted at the mine, as there are remains of ancient furnaces and slag.

8. At Um Semiuki at the foot of Gebel (mount) Abu Hamamid, about 50 kilometres from the coast north-west of Ras Benas, there are extensive ancient workings with several shafts. At the surface, the ore is malachite and azurite, of which there is a thickness of about seven metres and below this are copper and zinc sulphides and lead ore (the zinc sulphide containing silver). There are also ore crushers, pottery (possibly broken crucibles) and slag. These are the most important deposits of copper ore yet discovered in Egypt, some of the workings being 40 to 50 feet underground.[3]

In addition to the ancient slag heaps, already mentioned, situated at the various mines, there is also one where there are no mines, namely at Kubban on the east bank of the Nile opposite Dakka (Lat. 23° 10′ N.).[4, 5] The origin of the ore smelted is not certain, though it is often assumed to have been that from the Abu Seyal mine, part of which at least, however, was smelted at the mine, as the remains of ancient furnaces and slag attest.

Quality of Ore

Very few analyses of Egyptian copper ore have been made or published and the only ones that can be traced are as follows:

Sinai. (*a*) South-western mines. This ore yields from 5 to 15 per cent of copper according to Rickard[6] and up to 18 per cent according to Rüppell.[7] (*b*) South-eastern mines. A specimen of ore analysed by Professor Desch gave 3 per cent of copper.[8]

[1] Dr. J. Ball, private communication.
[2] J. Wells, *op. cit.*, p. 34.
[3] W. F. Hume, *Geology of Egypt*, Vol. II, Part III, pp. 837–42.
[4] J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, p. 353.
[5] C. M. Firth, *The Arch. Survey of Nubia, Report for 1908–1909*, p. 24.
[6] T. A. Rickard, *op. cit.*, p. 196.
[7] E. Rüppell, *Reisen in Nubien, Kordofan und dem petraischen Arabien*, p. 266.
[8] Result kindly supplied by Mr. G. A. Garfitt, Hon. Sec. Sumerian Committee, British Association.

Eastern Desert. (*a*) From Wadi Araba two specimens of ore analysed by the Chemical Department, Cairo, gave 36 and 49 per cent of copper respectively.[1] (*b*) It is stated that the Abu Seyal ore yields on an average well over 3 per cent of copper and that in places it is very rich and may give as much as 20 per cent.[2] (*c*) A specimen of ore from the Abu Hamamid mine gave 13 per cent of copper.[3]

Amount of Ore

Some evidence of the amount of ore dealt with anciently in certain districts may be obtained from the dimensions of the ancient slag heaps, but the data are very incomplete, and, even if it be assumed that all the heaps exist and are known, which almost certainly is not the case, many of them have neither been measured nor examined. The various slag heaps that are known have been mentioned already; but the only ones of which any particulars are given are those of Wadi Nasb, Seh Baba and Kubban, which may now be considered.

Slag Heap at Wadi Nasb. The dimensions of this given by Petrie in 1906 are 500 feet long, 300 feet wide and 6 or 8 feet high.[4] Petrie, however, quotes Bauerman (an English geologist who explored the district in 1868), for very different dimensions, namely 250 yards by 200 yards,[4] while another writer gives Bauerman's dimensions as being 350 yards by 250 yards by 8 or 10 feet.[5] Bauerman's own statement,[6] however, is that the slag forms a roughly elliptical heap, about 350 yards long and 200 yards in breadth, the depth being very variable and probably not more than 8 to 10 feet at the most, but that over the greater part of the area the slag forms only a thin coating on the rock. Mr. G. W. Murray of the Desert Surveys of Egypt, who measured the slag in 1929, found two heaps: '(1) An area roughly 230 × 110 metres, with an average depth of 1 metre; (2) an area of 100 × 60 metres, very irregular, but very thin.'[7]

Petrie's estimate for the amount of slag present is 100,000 tons, but

[1] Figures kindly supplied by Dr. W. F. Hume.
[2] J. Wells, *Report of the Dept. of Mines*, 1906, p. 34.
[3] Kindly communicated by Mr. R. S. Jenkins, Insp. Dept. Mines and Quarries.
[4] W. M. F. Petrie, *op. cit.*, p. 27.
[5] Anon., *The Copper of Sinai*, in *Mining and Scientific Press*, Sept. 1919, pp. 429–30.
[6] H. Bauerman, *Quart. Journal Geological Society*, xxv (1869), p. 29.
[7] G. W. Murray, private communication.

Rickard, taking Bauerman's measurements, makes the amount only 50,000 tons,[1] which seems much too small for the dimensions given (which are in yards for the length and breadth and not in feet, as is the case with Petrie's measurements) and if an average depth of only two feet be allowed the result would be 118,000 tons.

In order to arrive at the weight of the slag it is necessary to know, not only the measurements of the heap, but also the specific gravity of the material, and this does not seem to have been determined, but only guessed. In the absence of specimens of the Wadi Nasb slag, I determined the specific gravity of five specimens of similar copper slag from Seh Baba, which were found to vary from 3.1 to 3.5, with a mean of 3.36, and this will be assumed to be approximately correct also for the Wadi Nasb slag. On this basis the calculated weight of the slag is as follows:

(*a*) From Petrie's dimensions, 98,000 tons, which is very close to Petrie's own estimate of 100,000 tons.

(*b*) From Bauerman's dimensions, probably not less than 100,000 tons, since with an average depth of only two feet the amount would be 118,000 tons.

(*c*) From Murray's dimensions about 90,000 tons.

Rickard states that the slag contains 2.75 per cent of copper,[2] which on 100,000 tons of slag represents 2,750 tons of copper: he assumes this to be one-third the copper content of the ore and therefore that two-thirds of the copper, or 5,500 tons, were extracted.[3]

Slag Heap at Seh Baba. The dimensions of one heap as given by Petrie are 80 feet by 60 feet,[4] but another estimate is 50 feet by 50 feet by 1 foot.[5] Greaves, however, states that both these estimates are too high for the slag now present, but he also says that the heap is

[1] T. A. Rickard, *Copper and Gold Mines of the Ancient Egyptians*, in *Eng. and Mining Journal-Press*, June 20th, 1925, p. 1006.

[2] A specimen of slag, probably that from Wadi Nasb, analysed by Sebelien (*Ancient Egypt*, 1924, p. 10) contained 21.65 per cent of copper. This slag, however, is not only not of uniform composition, some being strongly fused and very hard, black and glassy-looking, and some being very green and only partly fused, but it contains metallic copper, both in large pieces and in coarse grains and, unless properly sampled by a competent person, an analysis of an isolated specimen is likely to be misleading. Mr. G. W. Murray informed me that one specimen analysed gave 2.3 per cent of copper.

[3] T. A. Rickard, *Man and Metals*, 1, pp. 196–7.

[4] W. M. F. Petrie, *op. cit.*, p. 18.

[5] By Mr. R. S. Jenkins, Insp. Dept. Mines and Quarries. Private communication.

gradually being washed away.[1] The specific gravity of the slag, as already stated, is 3.36. The weight of the slag, therefore, from the dimensions given, would be either 450 tons or 235 tons, according to which estimate is taken, and the amount of copper extracted, represented by this slag, would be either 25 or 13 tons.

Slag Heap at Kubban. This heap is 105 feet long and 13 feet broad,[2] but the height cannot easily be measured on account of the accumulated sand. Let it be assumed to be 2 feet. The specific gravity of the two specimens determined by the author was 2.8 and 3.0 respectively, or a mean of 2.9. The total amount of slag, therefore, is 220 tons and, if the amount of copper in the original ore and the proportion extracted be assumed to have been the same as for Sinai, this heap will represent about 12 tons of copper.

On the evidence of the slag heap at Wadi Nasb, the minimum amount of metallic copper yielded anciently by the Sinai mines up to the date of this heap (Twelfth Dynasty) amounted to a minimum of 5,500 tons, though probably more. This must be supplemented by the amount smelted at Magharah, Seh Baba, Gebel Safariat, the plain of Senned and the hill region of the extreme south-east, which together was probably considerable, though except for a portion of that from Seh Baba, no estimate is possible. To the copper from Sinai must be added that extracted from the mines of the eastern desert, for which the only basis for an estimate is the slag heap at Kubban, which certainly represents only a small fraction of the total ore smelted.

In any consideration of the total amount of copper yielded by the Egyptian mines and whether or not it could have been sufficient for the needs of the country until about the Eighteenth Dynasty, when admittedly copper was imported from Asia, it should not be forgotten that Egypt was then, as it still is, a comparatively small agricultural country where the greater proportion of the people did not use copper and more than 5,200 years after the first use of copper in Egypt, namely in the year 1800 A.D., or only 145 years ago, when copper was employed for many more purposes and very much more extensively than in ancient Egypt, the entire world's production only amounted to 10,000 tons.[3] In relation to the amount of copper used in ancient Egypt, the

[1] Mr. R. H. Greaves, formerly Controller Dept. of Mines and Quarries. Private communication.

[2] Kindly measured for the author by Tewfiq Effendi Boulos, Chief Inspector, Dept. of Antiquities, Upper Egypt, who also supplied specimens.

[3] R. Allen, *Copper Ores*, p. 1.

product of the Sinai and eastern desert mines must have been considerable and de Morgan's criticism that the quantity of ore from Sinai (he does not appear to have known of the eastern desert supply) was 'insignificant'[1] and that 'Egypt must be ruled out absolutely from among the copper-producing countries'[1] may be disregarded. Although Lepsius did mistake the manganese ore capping some of the Sinai peaks for copper slag (he writes of 'great slag-hills'[2] and 'artificial mounds' 'covered with a massive crest of slag')[2] this in no way either destroys or lessens the value of the facts respecting the number and extent of the ancient workings for copper ore and the ancient slag heaps that have been enumerated.

Date of earliest Mining

Owing to the fact that copper ore and turquoise were both mined at the only two localities in Sinai where inscriptions have been found, namely at Magharah and Serabit el Khadim, and that both materials were used at an equally early date[3] (as was also metallic copper) there is no certainty whether the earliest inscriptions refer to copper ore or to turquoise. That during the Old Kingdom some at least of the mining at Magharah was for copper ore is proved by the finding of mining settlements of that date with copper ore, crucibles, copper slag, waste scraps from smelting and an ingot mould.[4] The fact, too, that a copper axe-head of middle predynastic date[5] and also the copper of which certain metal bands of First or Second Dynasty date[6] were composed contained manganese, is a very strong indication that the original copper ore had been obtained from the neighbourhood of the manganese ore deposits in Sinai, that is probably from Magharah, and, if so, then the Sinai ore was being smelted for copper as early as the middle predynastic period.

A stela has recently been found in the desert south-east of Aswan dating from the reign of Sesostris I (Twelfth Dynasty), on which it is stated that a certain official named Horus had been ordered by the king

[1] J. de Morgan, *Prehistoric Man*, p. 114.

[2] R. Lepsius, *Discoveries in Egypt, Ethiopia and the Peninsula of Sinai*, p. 348.

[3] Copper ore (malachite), metallic copper and turquoise were all used in the Badarian period (G. Brunton and C. Caton-Thompson, *The Badarian Civilisation*, pp. 27, 41, 56). Mr. Brunton has informed me that the material originally classed doubtfully as turquoise has now been definitely identified as turquoise.

[4] W. M. F. Petrie, *op. cit.*, p. 51.

[5] See n. 9, p. 229.

[6] W. M. F. Petrie, *The Royal Tombs*, II, p. 40.

to collect ' copper of the Land of Nubia.' [1] This and the slag heap at Kubban are the sole evidence at present of any date in connexion with mining in the eastern desert, the fort at Kubban having certainly been occupied during the Empire, but not earlier than the Twelfth Dynasty.[2, 3, 4] It should be noted that in the enumeration of tribute taken by the Egyptians at various times from the peoples who dwelt to the south, there is no mention whatever of copper, thus suggesting that the copper mining in the eastern desert was always in the hands of the Egyptians and not of the Nubians. Strabo possibly refers to the eastern desert of Egypt when, in describing Ethiopia, he says that ' There are also mines of copper, iron and gold ' [5] and Diodorus has practically the same statement, namely, ' It is said there are in it (i.e. in Ethiopia) mines of gold, silver, iron and brass . . .,' [6] but the geography of this time was very vague and southern Ethiopia, which was in the Sudan, or even the Sudan generally, where such mines exist, may have been meant, rather than the northern part of Ethiopia, which was in Egypt.

The earliest references to the importation of copper into Egypt from abroad (excluding Sinai) are of the Eighteenth Dynasty in which, as also in the following dynasty (Nineteenth Dynasty), copper was received from Retenu[7] and Zahi[8] in Syria; from Arrapachitis[9] in western Asia (which is thought to be the modern Kirkuk, situated between the two branches of the Zab river in Mesopotamia); from Asia[10]; from God's Land[11] (a name used to designate several different and widely separated places, including countries in western Asia, the eastern desert of Egypt and Punt); and from Isy[12] (which is often stated to mean Cyprus, but which Wainwright has shown not to be Cyprus, but a country situated on the coast of north Syria[13]).

[1] Alan Rowe, Three New Stelae from the South-Eastern Desert, *Annales du Service des Antiquités de l'Égypte,* XXXIX (1939), pp. 188–91.

[2] C. M. Firth, *The Arch. Survey of Nubia, Report for 1909–10,* p. 5.

[3] A. E. P. Weigall, *A Guide to the Antiquities of Upper Egypt,* 1910, pp. 525–7.

[4] W. B. Emery and L. P. Kirwan, *The Excavations and Survey between Wadi Es-Sebua and Adindan, 1929–1931,* I, pp. 26–44.

[5] XVII: 2, 2. [6] I: 3.

[7] J. H. Breasted, *op. cit,* II, 447, 471, 491, 509, 790.

[8] II, 459, 460, 462, 490. [9] II, 512.

[10] II, 45, 104, 175, 614, 755; III, 217, 537, 910.

[11] II, 274. [12] II, 493, 511, 521.

[13] G. A. Wainwright, *Alashia=Alasa; and Asy,* in *Klio, Beiträge zur alten Geschichte,* 1913. (Original paging not given in reprint.)

Presents of copper from Alasia to Egypt in the Eighteenth Dynasty included 5 talents, 9 talents, 18 talents, 80 talents, 200 talents and 'much copper.' [1]

Copper Ores

The copper ores found in Egypt (including Sinai) are principally azurite, chrysocolla, malachite and sulphide, whose occurrence has already been dealt with in connexion with the ancient mines, but which may now be considered in greater detail.

Azurite is a beautiful deep-blue basic carbonate of copper that occurs in copper deposits and is found both in Sinai and in the eastern desert: being an oxidized product derived from the decomposition of copper sulphide, azurite always occurs at or near the surface and hence is found and worked easily: it does not occur in any great amount and is not nearly so plentiful as malachite, with which it is generally associated. Azurite was employed anciently in Egypt both as a source of metallic copper and as a pigment,[2] until for the latter purpose it was displaced by an artificial blue frit.

Chrysocolla is a blue or bluish-green ore of copper that chemically consists of the silicate: it occurs both in Sinai and in the eastern desert of Egypt, in both of which places it appears to have been worked anciently to a small extent as a source of metallic copper. Apart from this use of the ore and from its occasional employment as an eye-paint,[3] only one example of chrysocolla from ancient Egypt can be traced, namely, fashioned into a small figure of a child that was found in a predynastic grave at Hierakonopolis.[4, 5]

Malachite, the ancient Egyptian name of which was *shesmet*, is a green basic carbonate of copper that was the principal and earliest ore of copper used anciently, because, like azurite, it is an oxidized product derived from the decomposition of copper sulphide, and therefore is the ore found on the surface of most copper ore deposits: it occurs in Egypt both in Sinai and in the eastern desert, from one or both of which places the early supply was derived.

The use of malachite in Egypt goes back to the Tasian[6] and Badarian periods, from which time onwards, until at least the

[1] S. A. B. Mercer, *The Tell-el-Amarna Tablets*, I, pp. 191, 199, 205.
[2] See p. 392.
[3] See p. 101.
[4] J. E. Quibell and W. F. Green, *Hierakonopolis*, II, p. 38.
[5] J. E. Quibell and W. M. F. Petrie, *Hierakonopolis*, I, p. 7.
[6] G. Brunton, *Mostagedda*, pp. 6, 34.

Nineteenth Dynasty, it was employed as an eye-paint[1] : it was used, too, at an early date as a pigment for mural painting[2] and for other purposes, including the very important one of colouring glaze and glass,[3] and very occasionally also for making beads, amulets[4] and other small objects; but the principal value of malachite in Egypt was as a source of metallic copper, and it is the richest in copper of all the ores.

Copper Mining

Copper ores, principally malachite, almost certainly were obtained at first and for a long period entirely from surface deposits without any attempt at underground mining. For extracting the ore nothing more elaborate than crude stone (flint) tools would have been required; but for cutting shafts at a later date, to follow the vein of ore underground, copper chisels undoubtedly were employed and suitable chisels existed from the late predynastic period onwards. In the Sinai mines Petrie found evidence of the use of copper chisels only, and not of stone tools for cutting the rock.[5]

Copper Smelting

After the ore had been mined it probably was crushed and hand picked and then smelted.

At the present day copper is obtained from its ores by means of an elaborate series of complicated metallurgical operations conducted in special furnaces, the exact nature of the operation and the type of furnace used depending upon the kind of ore dealt with. It is not proposed to describe these methods, but the treatment in its simplest form of the oxidized class of ores, to which malachite belongs, may be mentioned. It consists in mixing the ore with coke and suitable fluxes and heating in a furnace provided with a blast. The ancient Egyptian substitute was to mix the broken ore with charcoal in a heap on the ground, or in a shallow pit, this sometimes being situated in a special position, such as the side of a hill, or in a valley, as in the case of the Wadi Nasb in Sinai, in order to take full advantage of the wind, the fact that a current of air caused the fire to burn more fiercely manifestly having been noticed at a very early period. At a later date bellows were used.

[1] See p. 99. [2] See p. 396. [3] See p. 198. [4] See p. 456.
[5] W. M. F. Petrie, *op. cit.*, pp. 48–9, 61, 161.

Currelly found in Sinai the remains of an ancient furnace that had been used for smelting copper ore: it consisted of a hole in the ground about two and a half feet deep surrounded by a stone wall, through which there were two blast holes.[1]

Since copper melts at 1,083° C. this is not an impossible temperature to have been obtained with the primitive methods suggested, if only a small quantity of ore were operated upon at one time. Coghlan states[2] that to smelt copper from malachite or other carbonate ore a temperature of 700° C. to 800° C. is sufficient.

As a result of experiments in simple methods of smelting copper ores to produce metallic copper, Coghlan suggests[3] that copper was first produced accidentally, not in a camp fire, hole in the ground, or other open fire, as is generally supposed, but in a pottery kiln, that is in a closed chamber. But metallic copper was known long before pottery kilns were used, and I suggest that metallic copper was first discovered in connexion with the glazing of steatite, or quartz, the latter being either solid, or powdered (faience core material), and I have pointed out[4] that a closed chamber must have been used for making glazed steatite, glazed solid quartz and faience. If this is accepted, then metallic copper must have been an Egyptian discovery.[5]

When the smelting was finished, the unburnt and partly burned fuel probably would have been removed, so as to allow the metal to cool, which then would have been broken up into smaller pieces for use, this possibly having been done when it had just become solid, at which stage copper is peculiarly brittle and easily broken up by hammering.[6] Gowland states[7] that this method of treating copper still survived in Korea in 1884.

As pointed out by Rickard,[6] the primitive method of smelting practised must have resulted in ' a spongy mass of metal, incompletely fused and containing extraneous matter.'

[1] C. T. Currelly, W. M. F. Petrie, *Researches in Sinai*, pp. 242–3.

[2] H. H. Coghlan, *The Antiquaries Journal*, 22 (1942), p. 27.

[3] H. H. Coghlan, Some Experiments on the Origin of Early Copper, *Man*, July 1939, No. 92.

[4] A. Lucas, Glazed Ware in Egypt, India and Mesopotamia, *Journal of Egyptian Archaeology*, XXII (1936), p. 156. See also p. 200 of this book.

[5] See *Journal of Egyptian Archaeology*, No. 31 (1945), pp. 96–7.

[6] T. A. Rickard, *Man and Metals*, I, p. 116.

[7] W. Gowland, The Metals in Antiquity, *Journal Royal Anthrop. Inst.*, XLII (1912), p. 241.

Copper Working

In order to shape the pieces of crude copper obtained by breaking up the mass (never very large) from the furnace and to fit them for use, necessarily they would have been hammered, since it would soon be discovered that copper was fairly soft and malleable, and this hammering would have consolidated the metal and would have freed it from some of the grosser impurities. At a later date the crude copper was probably re-melted in order to improve the quality. A crucible, probably for melting copper in order to re-melt it, or cast it, of Seventh to Eighth Dynasty date, was found by Brunton in the Qau-Badari district, of which he says[1] it 'is of rough grey clay or ash; the inside surface is vitrified in places and shows traces of copper slag. Outside it is coated with some kind of plaster. The opening is half-way down the side, and it has no spout. The height is about 5 inches.' Petrie also found crucibles that had been used for copper, of which, however, very few particulars are given.[2] As there were no such appliances at an early date as special tongs for holding hot metal, all hammering at first necessarily was done cold, which has been proved from the microscopical examination of ancient copper objects.

At a later period it was discovered that copper could be shaped more quickly and more easily by melting it and pouring it into moulds while liquid, the moulds being open ones. Petrie states[3] that they were 'cut out of a thick piece of pottery and lined smooth with fine clay and ash,' which seems unnecessarily complicated, since it would have been much simpler to have impressed the shape of a previously made object in wet clay and then dried and baked the clay, when it would have become a pottery mould. Stone moulds also were employed, a possible example being the one found in Sinai by de Morgan.[4] The earliest evidence of casting copper known to me is that of an axe-head of middle predynastic date found by Brunton and examined by Sir Harold Carpenter, who concludes 'that it was cast roughly to shape, and then either cold-hammered and annealed or hammered while hot.'[5]

[1] G. Brunton, *Qau and Badari*, I, pp. 36, 67; Pl. XLI (25).

[2] W. M. F. Petrie, (*a*) *Researches in Sinai*, pp. 51, 162; Pl. 161; (*b*) *Tools and Weapons*, p. 61.

[3] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 100.

[4] J. de Morgan, *op. cit.*, I, p. 229

[5] H. C. H. Carpenter, An Egyptian Axe Head of Great Antiquity, *Nature*, 130 (1932), pp. 625–6.

Blowpipes were used certainly as early as the Fifth Dynasty as they are depicted in a tomb of that date,[1] whereas bellows are not shown before the Eighteenth Dynasty.[2]

When the cast object was a dagger, knife, or chisel, the cutting edge naturally would have been hammered to thin and shape it, and this hammering would have hardened the metal considerably, a fact that hardly could have escaped notice long. If hammered too much, however, copper becomes brittle, which also soon would have been observed and avoided, since it is not likely that the remedy for brittleness would have been discovered until much later. This remedy is to heat the copper to a temperature of from about 500° C. to 700° C. for a short time, the process being known as annealing or tempering, the tempering of copper being the softening and not hardening, as sometimes is wrongly stated. The only secret of hardening the ancient Egyptians knew was to hammer it, and the 'lost art' so often referred to is a myth. In an experiment made by Desch it was shown that copper with an initial hardness (Brinell scale) of 87 was raised to a hardness of 135 by hammering.[3] Modern steel tested in the same manner varies from 100 to 800.[4] The process of hammering 'produces an abnormal state of crystallization in which copper is harder than in the ordinary state. The abnormal state . . . would have relaxed after a certain time and the copper would have again assumed its ordinary soft state of crystallization.'[5]

The Egyptians became very expert at an early date in the art of working copper, perhaps the most remarkable examples of this being the large statue of Pepi I (Sixth Dynasty) and the accompanying small statue, which are the oldest Egyptian metal statues

[1] G. Steindorff, *Das Grab des Ti*, p. 134.

[2] P. E. Newberry, *The Life of Rekhmara*, Pl. XVIII. N. de G. Davies, (*a*) *The Tomb of Puyemrê*, Pl. XXVI; (*b*) *The Tomb of Two Brothers*, Pl. X. N. and N. de Garis Davies, *The Tomb of Menkheperrasonb, Amenmose and Another*, Pl. XII.

See also the following-named Sixth, Twelfth and Eighteenth Dynasty tombs: N. de G. Davies, *The Rock Tombs of Deir el Gebrâwi*, I, Pl. XIV; II, Pls. X, XIX. P. Duell and Others, *The Mastaba of Mereruka*, I, Pls. 30, 32. P. E. Newberry, *Beni Hasan*, II, Pls. IV, VII, XIV. N. de G. Davies, *The Tomb of Two Officials*, Pl. VIII; *The Tomb of Two Sculptors*, Pl. X; *The Tomb of Puyemrê*, Pls. XXIII–XXV.

[3] C. H. Desch, The Tempering of Copper, *Discovery*, VIII (1927).

[4] Sir R. A. Hadfield, *Metallurgy of Iron and Steel*, 1922, p. 44.

[5] T. W. Richards, *Mycerinus*, G. A. Reisner, p. 232.

known,[1] one of them being also the largest. The metal of which these statues consist is often stated to be bronze, on the strength of an analysis quoted by Maspero[2] (who disregards it and calls the metal copper), which was made by Professor Mosso of Rome and shows 6.6 per cent of tin. There is, however, considerable probability that some confusion of samples occurred and that the specimen examined was not from the statues. The material was examined also by Dr. Gladstone,[3] who reports that the presence of tin was doubtful. I analysed a sample taken by myself from the larger statue and found the metal to be copper free from tin, and since then Professor Desch has published a detailed analysis showing 98.2 per cent of copper and no tin.[4] With respect to these statues it has never been established definitely whether they were hammered to shape, or cast, both opinions having been expressed, but, in my opinion, casting, which would have had to be done in closed moulds, would have been impossible at that period on account of the blistering that takes place due to the absorption of gases from the atmosphere when the copper is being melted and the giving off of these gases again when the copper cools. What seem to be the earliest casting of copper in closed moulds known in Egypt are the four copper boxes found by the French Archaeological Expedition at Tôd in Upper Egypt,[5] two of which measure approximately $30 \times 19 \times 13$ cm., and two $45 \times 29 \times 19$ cm., the metal being one millimetre thick. The lids slide in grooves, and on the bottom of each box there are two cross pieces. Over large areas the metal is pitted with holes, which I believe to be ' blow ' holes and not the result of corrosion, although the boxes were corroded superficially. On the larger of the two boxes in the Cairo Museum,[6] which I cleaned, there is a small patch on the under side of the lid and a very large patch (about half the area of the bottom) on the bottom.

[1] ' The Pepi statues were not the most ancient of their kind in Egypt. The Palermo stone records the making of a copper statue of Khasekhemui (Second Dynasty).' H. R. Hall, *The Art of Egypt through the Ages*, edited by Sir E. Denison Ross, p. 17, and Sethe states that in the Fifth Dynasty there were two copper sun-boats, each eight ells long (K. Sethe, *Journal of Egyptian Archaeology*, 1 (1914), pp. 233–6).

[2] G. Maspero, *Guide to the Cairo Museum*, Eng. trans. 1910, p. 73.

[3] J. H. Gladstone, *Dendereh*, W. M. F. Petrie, pp. 61–2.

[4] C. H. Desch, Report on the Metallurgical Exam. of Specimens for the Sumerian Committee of the British Assn., *Report of the British Assn.*, 1928.

[5] F. B. R., Tôd (1934–36), *Fouilles de l'Inst. franç. d' arch. orient. du Caire*, XVII (1937), pp. 119–20.

[6] Two of the boxes are now in the Louvre Museum, Paris.

These I suggest are places where the casting failed. Although the contents of the boxes were non-Egyptian, it seems highly probable that the boxes were made in Egypt, since the inscriptions on them are in Egyptian hieroglyphs.

As excellent early examples of copper objects, the ewer and basin found by Reisner in the tomb of Hetepheres (Fourth Dynasty)[1] may be mentioned. The basin and body of the ewer have been hammered to shape, but the spout of the ewer has been cast and inserted, probably being fixed merely by cold hammering, since welding, brazing and the use of soft solder were not discovered until much later. Garland and Bannister state[2] that 'there is no positive evidence of welding or brazing of copper or bronze or of soft soldering before late Roman times.' Petrie,[3] and also Fink and Kopp,[4] mention other similar ewers and basins from royal tombs made in the same manner. At least one ewer of Old Kingdom date has the spout fastened on with copper rivets.[5]

Although soft solder was not known until late there is an example of hard solder used for joining copper in the tomb of Hetepheres. When I was cleaning the cylindrical copper sockets in which the upright poles of the canopy rested (which are made of sheet copper formed into a cylinder with the two ends overlapping where they meet) a thin silver-white layer was noticed on both sides of the joints and between the two layers of copper. This on testing was found to consist largely, if not wholly, of silver, though the presence of a small proportion of copper cannot entirely be excluded, and it had manifestly been used as a solder. The composition of solder from a bronze flute of late date agreed 'almost entirely with the best quality solder in present-day use.'[6] The tubes of both the silver and copper trumpets from the tomb of Tut-ankhamun are soldered and apparently with silver.

The plating of copper both with silver,[7] of which one example is known, and with gold,[8] of which there are numerous instances, also was practised.

[1] G. A. Reisner, The Tomb of Hetep-heres, *Bull. Mus. of Fine Arts (Special Number) Boston*, xxv (1927), p. 31.
[2] H. Garland and C. O. Bannister, *Ancient Egyptian Metallurgy*, p. 69.
[3] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 99.
[4] C. G. Fink and A. H. Kopp, *Metropolitan Museum Studies*, IV (1933), pp. 164–5.
[5] Cairo Museum, No. J. 66924.
[6] Sir R. Mond and O. H. Myers, *The Bucheum*, I, p. 107.
[7] See p. 283.
[8] See p. 265.

Thin sheet copper was used certainly as early as the First Dynasty for covering wood and was fastened on with copper nails, and narrow bands of thin copper were employed at an early date for binding joints in wood.

From the analyses of ancient copper objects,[1] it is evident that (as is only to be expected) the copper employed was never pure, but always contained small proportions of other ingredients, the most common of which were antimony, arsenic, bismuth, iron, manganese, nickel and tin, the total impurities generally amounting to less than one per cent, though occasionally they were more. All these impurities were derived accidentally from the ore employed, and, with the exception of the bismuth, which would be deleterious, they would harden the copper.

Statements are made sometimes with reference to the impurities in copper such as that 'Various small amounts of alloys were used to harden it, probably by mixing ores for reduction; bismuth, manganese, arsenic and tin are thus found used'[2] and 'Down to this age copper was used with only small amounts of hardening mixture.'[3] These statements, attributing to intention what was merely the result of natural conditions, are not only contrary to all probability, but are entirely unsupported by evidence. The only constituent added intentionally to copper in Egypt was at first tin, which produced bronze, and, at a later period, lead, which made the bronze easier to cast.

Bronze

The word bronze as used to-day has a wide meaning, and includes a number of different alloys consisting wholly or largely of copper and tin, but in some cases containing also small proportions of other ingredients, among which zinc, phosphorus and aluminium may be mentioned. Early bronze, however, was much simpler and consisted only of copper and tin, with traces of such other ingredients as happened to be present in the raw materials employed. At a later date, as already mentioned, an addition of lead sometimes was made, but such an admixture although of the bronze class, is not a typical or normal bronze. At the present day, ordinary bronze contains about 9 to 10 per cent of tin, but ancient bronze is more variable, the

[1] See pp. 542–3.

[2] W. M. F. Petrie, (*a*) *Social Life in Ancient Egypt*, pp. 149–50; (*b*) *Egyptian Architecture*, p. 31.

[3] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 100.

proportion of tin ranging from about 2 per cent to about 16 per cent. Tin in less proportion than about 2 per cent is due generally to the presence of a small amount of tin oxide in the copper ore, and it would be misleading to consider such a mixture to be bronze, since the production of the artificially-made alloy marks a definite stage in the history of early civilization that it is convenient and desirable to keep separate from the still earlier stage when the only metal employed was copper, although this copper was sometimes impure and might contain a trace of tin.

The advantages of bronze over copper are (*a*) that by the addition of small proportions of tin, up to about 4 per cent, the strength and hardness of copper is increased, particularly when hammered, though as much as 5 per cent of tin produces an alloy that becomes brittle when hammered, unless frequently annealed during the process.[1] At what date the danger of too much tin and the remedy of annealing for an overdose were discovered is not known; (*b*) that an addition of tin lowers the melting point of copper (copper, m.p. 1,083° C.: copper 95 per cent, tin 5 per cent, m.p. 1,050° C.: copper 90 per cent, tin 10 per cent, m.p. 1,005° C.: copper 85 per cent, tin 15 per cent, m.p. 960° C.)[2]; (*c*) that tin 'notably increases the liquidity of the melt, thereby facilitating casting operations. Here we have the chief advantage of converting copper into bronze. Copper is a bad metal for casting, not only because it contracts on cooling . . . but on account of its tendency to absorb gases and to become porous thereby. The presence of tin checks the absorption of oxygen and other gases.'[3]

The early history of bronze is obscure, but one fact is certain, namely, that it was not discovered in Egypt, since, although it is now known that tin ore occurs in Egypt, there is no evidence and little probability that it was known or worked anciently, and more especially because bronze was used in western Asia a considerable time before it reached Egypt. Although claims have been made for both Europe and Africa, there is no doubt that bronze was an Asiatic discovery[4] and it has been found at Ur as early as about

[1] T. A. Rickard, *op. cit.*, pp. 131, 134.

[2] J. W. Mellor, *Inorganic and Theoretical Chemistry*, VII, p. 355. Vickers (C. Vickers, *Metals and their Alloys*, 1923, p. 294), quoted by Rickard (T. A. Rickard, The Primitive Smelting of Copper and Bronze, in *Trans. Inst. Mining and Metallurgy*, 1934–35, p. 247) gives lower figures, namely 1,040° C., 994° C. and 944° C. respectively.

[3] T. A. Rickard, *op. cit.*, p. 132.

[4] This subject will be considered further in connexion with tin; see p. 288.

3500 B.C. to 3200 B.C.[1, 2] and the knowledge of it must have spread from Asia to Egypt and later to Europe. Although used so early at Ur, bronze cannot have originated in southern Mesopotamia, since this country contains no metallic ores.

The simplest assumption to make with regard to the discovery of bronze is that it was an accident, and there are only four possible ways in which it could have happened, namely, first, by fusing together metallic copper and metallic tin; second, by smelting a mixture of copper ore and metallic tin; third, by smelting the naturally-occurring combined mineral of copper and tin (stannite); and fourth, by smelting either a naturally-occurring or artificially-made mixture of copper ore and tin ore. The first two methods are out of the question, unless tin were known before bronze, and all the evidence available points to a later knowledge. The third method is most improbable, not only because the combined copper-tin mineral, stannite, occurs only in small quantities and in a few localities and because, if ever it had been employed, it could never have led either to the use of the principal and only important ore (cassiterite), for the use of which at a later period there is ample proof, or to the production of metallic tin, but also because the resulting bronze would have contained a much larger proportion of tin and more sulphur than is found in early bronze. In one locality in China a lode of stannite is worked at the present day. 'The metal obtained on smelting . . . contains 42.57 per cent of tin, 49.7 of copper, 1.3 of sulphur and 1.8 of lead.'[3] Desch says,[4] too, that 'The analyses of the early bronzes offer no support for the suggestion that they were obtained accidentally by smelting minerals which contain both copper and tin. Such minerals are always of a complex character, and would not give rise to such pure alloys as the early bronzes are found to be. It would appear, therefore, that these bronzes have been made by mixing oxide ores of copper and tin, which must have been done deliberately.' Later, however, Desch said[5] 'It seems natural to suppose that a mixed ore of copper and tin was used

[1] C. H. Desch, *Report on the Metallurgical Examination of Specimens for the Sumerian Committee of the British Association*, in *British Association Report* for 1928, pp. 437–41.

[2] H. J. Plenderleith, in *Ur Excavations, II, The Royal Cemetery*, C. L. Woolley, p. 290.

[3] G. M. Davies, *Tin Ores*, p. 86.

[4] C. H. Desch, *Third Report of the Sumerian Committee*, in *Report of the British Association*, 1930.

[5] C. H. Desch, *Excerpt Trans. Newcomen Society*, XIV, 1933–34.

for the early alloys, so that the first bronzes were produced accidentally.

Excluding, therefore, naturally-occurring minerals containing both copper and tin compounds, one is thrown back on an artificially-made mixture of the two ores, which, however, need not have been intentional in the first place, but which might have happened from the accident of the two ores having been found in close proximity to one another, as sometimes they occur, but only in such a locality, as until bronze was known there was no inducement to transport tin ore from one place to another.[1]

Being of foreign origin, bronze naturally would have been scarce in Egypt for some time after it first became known and a considerable period would have elapsed before the new alloy was widely used, which is exactly what has been found. It is always assumed that, though at first imported, bronze was made eventually in Egypt, using imported copper and tin, but for this there is no direct proof. Since, however, other countries in the eastern Mediterranean (for example Greece) made bronze—otherwise there would have been no use for the tin from the west to the commerce in which Herodotus and other classical writers bear testimony—it is not unreasonable to suppose that Egypt was no exception.

Owing to the lack of a large series of chemical analyses of early Egyptian metal objects, there is still some uncertainty about the date when bronze was used first in the country. It is not unusual, too, to find in archaeological reports objects called copper or bronze without any discrimination and sometimes even called copper in one part of a report and bronze in another, as though the terms were synonymous. Disregarding these loose statements, there are a few specimens of undoubted bronze that have been assigned to early periods, which may now be considered. The first in chronological order is a small piece of rod about 1½ inches long with a square cross-section found by Petrie at Medum,[2, 3] which, if contemporaneous with the material among which it was found, 'must be of the age of Seneferu'[2] (Fourth Dynasty, about 2900 B.C.). The finder calls it a 'freak'[4] and, although he believes it to be of the age stated, he admits that 'The only doubt

[1] This subject has been discussed at length by me elsewhere. (A. Lucas, *Notes on the Early History of Tin and Bronze*, in *Journal of Egyptian Archaeology*, XIV (1928), pp. 106–7).

[2] W. M. F. Petrie, *Medum*, p. 36.

[3] J. H. Gladstone, in *Proc. Soc. Bibl. Arch.*, XIV (1892), pp. 224–5.

[4] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, p. 104.

can be whether it fell in from above during the work, as I did not find it myself.'[1] After this comes a ring dated by de Morgan to a little after the end of the Third Dynasty,[2] but stated by Berthelot to be of uncertain date.[3] The next in date order is a thin razor stated by Sir Robert Mond to be of the Fourth Dynasty, which on analysis by Professor Desch proved to be bronze containing 8.5 per cent of tin.[4] Then comes a vase described as of the Sixth Dynasty, but about which no details are given.[5] From the Eleventh Dynasty there is a bowl[6] (but as this is merely stated to come from Luxor, without any further details, the dating may be wrong) and also a statuette (found at Meir and said to be the oldest bronze statuette known).[6] Not later than the Twelfth Dynasty are two bowls found by Garstang at Beni Hasan,[7] but as the analyst merely states that tin was present without giving the proportion, conceivably they might be of copper with a small natural admixture of tin, and not bronze. From this same dynasty there are a number of well-authenticated specimens of bronze including tools,[8] and the Middle Kingdom, therefore, may be considered as the beginning of the Bronze Age in Egypt. From the Eighteenth Dynasty[8] onwards bronze is well known and during the later periods it was employed extensively for casting small statuettes. The use of bronze, however, did not preclude a considerable use of copper; for instance in the tomb of Tut-ankhamun there was more copper than bronze. Among the copper objects from this tomb there are a number of miniature implements belonging to the *shawabti* figures, which I analysed and found that generally they consisted of copper entirely free from tin or containing only a trace, though in a few instances there was a somewhat larger proportion, estimated to be not more than about 2 per cent.[9] One of the large metal tongues, too, from the shrines

[1] W. M. F. Petrie, *Medum*, p. 36.

[2] J. de Morgan, *Recherches sur les origines de l'Égypte*, pp. 211–2.

[3] M. Berthelot, *Étude sur les métaux*, in *Fouilles à Dahchour*, J. de Morgan, 1895, pp. 135, 139.

[4] C. H. Desch, *Report of the British Association*, 1933. No evidence for the date of this object is given.

[5] G. B. Phillips, *The Composition of some Ancient Egyptian Bronzes*, in *Ancient Egypt*, 1924, p. 89.

[6] J. de Morgan, *op. cit.*, p. 204.

[7] J. Garstang, *The Burial Customs of Ancient Egypt*, pp. 43, 143, 144.

[8] For references, see p. 544. See also H. E. Winlock, *The Treasure of El Lahun*, pp. 62, 63, 73, 74, and G. A. Wainwright, *Antiquity*, 17 (1943), pp. 96–8; *Man*, XLIV (1944) No. 75.

[9] A. Lucas, *Appendix II*, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter, p. 175.

that surrounded the sarcophagus, was tested also and proved to be of copper and probably, therefore, all the similar tongues are copper. Dr. A. Scott found the metal band round the base of the outermost shrine to be copper containing 2.5 per cent of tin.[1]

In this connexion it may be mentioned that although occasionally it may be possible to distinguish an ancient copper object from one of bronze by mere inspection, as for instance in the case of thin objects of beaten copper, it is never safe to trust to this for identification and certainty can come only from a chemical analysis.

Wainwright puts the date of bronze making in Egypt about 1500 B.C.[2]

Bronze Working

Bronze, like copper, was worked by being either hammered or cast. The value of hammering is shown by two experiments made by Desch,[3] in one of which bronze containing 9.31 per cent of tin, which had an initial hardness (Brinell scale) of 136, after hammering gave a hardness of 257, and, in the second of which, bronze containing 10.34 per cent of tin gave figures before and after hammering of 171 and 275 respectively, which, as Desch points out,[3] ' represent a very considerable hardness.'

Bronze was employed extensively in Egypt at a late date for making statuettes, which were cast either solid or hollow, the smaller ones usually being solid and the larger ones hollow, the limbs in human figures, especially the arms, often being cast separately and attached by means of mortise and tenon joints provided for in the casting. The method of casting[4] was that known as the *cire perdue* (lost wax) process, the simplest form of which, as used for solid castings, was as follows: A model in beeswax was made of the object to be cast: this was coated with a suitable material to form the mould, probably clay or a clay mixture, and embedded in sand or earth, which acted merely as a support: the whole was then heated, when the wax melted and

[1] A. Scott, *Appendix IV*, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter, p. 205.

[2] G. A. Wainwright, Egyptian Bronze-Making, *Antiquity*, 17 (1943), pp. 96–8; 18 (1944), pp. 100–2.

[3] C. H. Desch, *The Tempering of Copper*, in *Discovery*, VIII (1927).

[4] See C. C. Edgar, (*a*) *Greek Bronzes*, pp. ii, iii; (*b*) *Greek Moulds*, pp. vi–xi; G. Roeder, Die Technische Herstellung der Bronzewerke, pp. 187–208, in *Ägyptische Bronzewerke*; also P. Coremans' review of Roeder's book in *Chronique d'Égypte*, No. 25, 1938, pp. 125–7.

either burnt away or ran out through the hole or holes provided to receive the molten metal and the mould became hard and rigid and ready for use: then the molten metal was poured in and allowed to cool, after which the mould was broken away and the object given the necessary finishing touches with a chisel.

The casting of hollow objects was merely a modification of solid casting, manifestly introduced for the sake of economy, since the amount both of wax and of metal was reduced considerably. In this method, a core of quartz sand (probably mixed with a small proportion of organic material to give it sufficient plasticity to enable it to be roughly shaped) was covered with a thin coating of beeswax and the whole fashioned into the required form, which was then treated as described for solid casting, namely, by covering it with clay or clay mixture to form the mould, embedding it in sand or earth as a support and heating it, when the wax burnt off or escaped and the outer shell became hard and rigid. The molten metal was poured into the space occupied previously by the thin layer of wax between the inner core and the outer mould, and when the metal was cold the jacket was chipped away, the core as a rule being left. A hollow-cast bronze head from a statuette of Ramesses II is in the British Museum.[1]

Several specimens of core material from Egyptian bronze statuettes examined by me all consisted of blackened sand, that is, sand the particles of which were coloured black and not merely mixed with black material. The black was chiefly an iron compound together with occasionally a very small proportion of organic matter. Petrie also describes the core material as blackened sand,[2] but Edgar calls it 'a hard, gritty light coloured composition like sand and plaster.'[3]

In what manner the core was fixed in the mould to prevent it moving about after the wax had melted and run out and before the metal was introduced is not known,[4] except that at a late date cross-supports of iron were employed.[5]

The process of casting metal (described in an accompanying inscription as from Syria) into the form of doors for the temple of Amun at Karnak is shown in the tomb of Rekhmara at Thebes (Eighteenth

[1] *British Museum Quarterly*, XI (1936), p. 32.
[2] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 101.
[3] C. C. Edgar, *Greek Bronzes*, p. ii. See also C. G. Fink and A. H. Kopp, *Technical Studies*, 7 (1939), pp. 116–7.
[4] W. M. F. Petrie, *Arts and Crafts of Ancient Egypt*, 1910, p. 102.
[5] H. Garland and C. O. Bannister, *Ancient Egyptian Metallurgy*, pp. 39–40.

Dynasty).[1] The name of the metal being employed is translated as copper or bronze, but it is almost certainly bronze, since the mould is certainly a closed one, for which copper would have been most unsatisfactory, especially for such a large object as a door, and bronze, besides being easier to manipulate, would have given much better results. Similar scenes of casting are depicted also in two other Eighteenth Dynasty tombs at Thebes.[2] Of what material the moulds were made it is impossible to determine from the illustrations. Half a closed stone mould for casting something in the nature of ornamental metal heads for poles or feet for furniture is in the Cairo Museum.[3] Garland and Bannister state that this 'was clearly used for making shell castings in the manner in which cheap statuettes are produced to-day, by filling the mould and, when a skin had solidified, pouring off the remaining liquid metal.'[4]

Brass

Another alloy of copper is brass, which is a copper-zinc mixture, but this was not known until comparatively late in the history of metals, though it antedated by many hundreds of years the discovery of zinc as an individual substance and, therefore, brass, as at first produced, must have been made from copper or copper ore and zinc ore, but not from metallic zinc, and, like bronze, probably it was at first the result of an accident. Ores containing both copper and zinc compounds sometimes are found in nature, for example, in Egypt,[5] Georgia and Caucasia.

Brass was being shipped down the Red Sea from or through Egypt to Adulis (Massowa) in the first century A.D.[6] and brass finger rings and earrings of late date have been found in Nubian graves.[7, 8]

[1] P. E. Newberry, *The Life of Rekhmara*, p. 37; Pl. XVIII.

[2] N. and N. de G. Davies, *The Tomb of Menkheperrasonb, Amenmose and Another*, Pl. XI; N. de G. Davies, *The Tomb of Puyemrê at Thebes*, Pl. XXVI.

[3] No. J. 37554.

[4] H. Garland and C. O. Bannister, *Ancient Egyptian Metallurgy*, p. 55.

[5] See p. 236.

[6] W. H. Schoff, *The Periplus of the Erythraean Sea*, p. 24.

[7] C. L. Woolley and R. D. Randall-MacIver, *Karanog*, pp. 62, 66.

[8] C. M. Firth, *Arch. Survey of Nubia, Report for 1910–1911*, pp. 115, 157, 159, 165.

Gold and Electrum

Gold

Gold is found very widely distributed in nature, chiefly in the metallic state, though practically never pure, but generally containing small proportions of silver,[1] sometimes copper and occasionally traces of iron and other metals. It occurs generally in one of two forms, either in alluvial sands and gravels, derived from the breaking down of gold-bearing rocks the debris from which has been washed into watercourses, now often dry, or in veins in quartz rock. In Egypt, gold is found in both these conditions. Owing to its local occurrence, its glittering yellow colour and to the simplicity of the treatment required to separate it for use, gold was one of the oldest metals known in Egypt, though not so old as copper, and it has been found in predynastic graves. Since the extraction of gold from sand and gravel is a simpler process than its extraction from hard rock, primitive races have usually begun gold mining with alluvial gold and the Egyptians probably were no exception to the rule.

The gold-bearing region of Egypt, which is 'immense,'[2] lies between the Nile valley and the Red Sea, chiefly in that part of the eastern desert stretching south from the Qena-Quseir road to the Sudan frontier, though several old workings have been found considerably north of the latitude of Qena, and many others lie beyond the confines of Egypt in the Sudan almost as far south as Dongola.[3] The greater part of this territory is in Nubia, the Ethiopia[4] of the classical writers, the modern Egyptian portion being Lower Nubia[5] (from Aswan to Wadi Halfa) and the Sudan portion Upper Nubia (from Wadi Halfa to Merowe). Referring to Ethiopia, Herodotus says 'here is great plenty of gold.'[6] Dunn says 'Traces of ancient mining are found all

[1] Sometimes gold objects have irregularly-distributed patches of silver, examples of which occur in the gold finger and toe stalls from the Twenty-second Dynasty tomb of Sheshonq found at Tanis in 1939 and from the tomb of another Sheshonq found at Mitrahineh.

[2] A. Llewellyn, in *Bull. Institution of Mining and Metallurgy*, 352 (1934), p. 23.

[3] Stanley C. Dunn, *Notes on the Mineral Deposits of the Anglo-Egyptian Sudan*, p. 13.

[4] The term Ethiopia was employed very loosely and Abyssinia (the modern inhabitants of which call themselves Ethiopians) and the southern Sudan were sometimes included, though generally the ancient Ethiopia geographically was the equivalent of modern Nubia and did not include Abyssinia.

[5] Nubia did not become a part of Egypt until the Twelfth Dynasty.

[6] III: 114.

over the Sudan north of the 18th parallel of latitude and there are at least eighty-five important old workings which can with certainty be imputed to the Egyptians or Mediaeval Arabs prior to the 10th century A.D.'[1] No occurrence of gold is known in Sinai, although the geological conditions are favourable and although some of the ancient records might seem to imply that gold was obtained from that region.

Referring to alluvial (placer) gold, Rickard says it[2] is reported that in a particular district in the eastern desert there are alluvial workings of 'immense extent,' the country having 'the appearance of having been ploughed' and that over an area of 100 square miles the ground has been worked to an average depth of seven feet, and Stewart states[3] that 'the whole of the small valleys in the schists are full of alluvial workings.' Some of these alluvial workings probably are comparatively modern, since gold was exploited in the eastern desert in Arab times. A few years ago Mr. A. H. Hooker, working on behalf of the Egyptian Government, found a very small amount of alluvial gold in the Wadi Korbiai in the south-eastern desert.

The total number of ancient workings in quartz has been estimated to be at least one hundred. Some of the mines were worked to a depth of about 300 feet. The ancient dumps are so poor in gold that the methods of extraction, primitive though they were, must have been very thorough.

But whether alluvial (placer) deposits or veins in quartz rock, the ancient Egyptians 'were very thorough prospectors and no workable deposits have been discovered that they overlooked.'[4]

The gold industry in Egypt was revived some years ago[5] and, although it has now died down again, 84,074 ounces of fine gold of a value of over £357,914 sterling were extracted during the eighteen years from 1902 to 1919 inclusive, but during the following eight years, from 1920 to 1927 inclusive, only 2,867 ounces of a value of £13,106

[1] Stanley C. Dunn, *loc. cit.*

[2] T. A. Rickard, *Copper and Gold Mines of the Ancient Egyptians*, in *Eng. and Mining Journal-Press*, 1925, p. 1008.

[3] P. C. Stewart, quoted by W. F. Hume in *A Prelim. Rept. on the Geol. of the Eastern Desert of Egypt*, p. 54.

[4] R. H. Greaves and O. H. Little, *The Gold Resources of Egypt*, in *Report of the XV International Geol. Congress, South Africa*, 1929, pp. 123–7.

[5] R. H. Greaves and W. F. Hume, in W. F. Hume, *Geology of Egypt*, Vol. II, Part III, pp. 723–60.

were extracted.[1, 2] Mining was discontinued, not because the gold was exhausted, but on account of the difficulty and cost of the work.

In view of the large amount of gold obtained in modern times and of that still remaining, there cannot be any doubt that the gold from the local mines provided most of the gold used in Egypt anciently, especially during the earlier periods, and that it was even sufficient to permit of export, as is proved by the El Amarna letters. Naturally, however, whenever possible additional gold was levied as tribute or taken as one of the fruits of victory after war, since it was a valuable and desirable metal to possess. The ten gold ingots weighing 6.5 kilograms of Twelfth Dynasty date found at Tôd in Upper Egypt were probably presents from abroad.[3]

Petrie's statements that 'The Asiatic gold was certainly used in the first dynasty, as it is marked by having a variable amount of silver alloy, about a sixth,'[4] and that 'Gold from the Ist to the XIIth dynasty averages 16 per cent of silver, which marks it as Pactolan and not Nubian,'[5] are based on a misconception of the nature of Egyptian gold, which always contains silver and often 16 per cent or more, as will be shown later. Petrie says also that in the Second Dynasty gold 'had antimony in it, which suggests a Transylvanian source, the telluride of gold and antimony.'[5] This has reference to the sard and gold sceptre of Khasekhemui, which was found by him at Abydos.[6] Peake and Fleure, elaborating Petrie's statement, say[7] '. . . a fragment of gold, found in the tomb of King Khasekhemui . . . has a red antimoniate crust.[8] Antimony combines with gold, so far as is known, only in the presence of tellurium, and the only region in the Old World in which gold and tellurium occur mixed is within the ring of the Carpathian mountains. The only rich gold-field within this ring is in Transylvania, where gold has been worked at least from Roman times onwards. . . . Meanwhile we note the possibility that gold from Transylvania found its way to Egypt about 3000 B.C.'

[1] R. H. Greaves and O. H. Little, *loc. cit.*

[2] Mines and Quarries Dept., (*a*) *Report on the Mineral Industry of Egypt*, 1922, pp. 23, 50; (*b*) *Report for 1928*, pp. 24–5, 44.

[3] F. B. R., *Tôd (1934 à 1936) Fouilles de l'Inst. franç. du Caire*, XVII (1937), pp. 116–8.

[4] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 83.

[5] W. M. F. Petrie, *Descriptive Sociology, Ancient Egyptians*, 1925, p. 57.

[6] W. M. F. Petrie, *The Royal Tombs*, II, 1901, p. 27; Pl. IX.

[7] H. Peake and H. J. Fleure, *Priests and Kings*, 1927, pp. 14–5.

[8] This object is in the Cairo Museum, and no red coloration can be found on it.

Peake, writing later, is slightly more definite and says[1] that 'Gold from Transylvania seems to have reached Egypt before the close of the 2nd dynasty.' Heard repeats this statement in a still stronger form.[2] Professor Myres, in referring to this gold,[3] makes two slips, one in calling the ingredient that was found in the gold tellurium instead of antimony, there being no evidence that the gold contained tellurium, and the other in terming it a 'high percentage,' whereas no statement of the proportion in which the antimony occurred has been made.[4] Since the origin of the early Egyptian gold is an important matter, these various statements about a possible Transylvanian source may be examined. Petrie says that the gold in question contained antimony, which is not doubted, as it is understood that the analysis was made by Dr. Gladstone. The proportion in which the antimony occurred, however, is not given,[4] which is to be regretted, since this information would have been valuable, but presumably it was present only in small amount, possibly as a trace. An ancient method of refining gold (how ancient is not known) was by means of sulphide of antimony, which was very liable to leave a little antimony in the gold, though, as this method was certainly not practised as early as the Second Dynasty, this does not explain the antimony in the particular gold under consideration, but it does show that the presence of antimony in gold is no proof that the gold was obtained from Transylvania.

The statement that, so far as is known, antimony combines with gold only in the presence of tellurium, is also misleading, since antimony alloys readily with gold in practically all proportions without the help of tellurium, and no evidence can be found that antimony ever forms a red antimoniate of gold.

That the gold in question was obtained from Transylvania and, therefore, that gold, especially in the form of such an ore as gold telluride, was being worked there and traded to Egypt (a country where gold occurred in abundance and was well known at the time) even in small amount, as early as the Second Dynasty (about 3000 B.C.) is so improbable that it may be disregarded. Moreover, gold telluride is grey in colour and therefore not like gold in appearance and hence probably

[1] H. Peake, Article 'Gold,' in *Ency. Brit.*, 14th ed. (1929), Vol. 2, p. 252.
[2] G. Heard, *The Emergence of Man*, p. 161.
[3] J. L. Myers, *The Discovery and Early Use of Metals*, in *Early Man*, 1931, p. 143.
[4] Not published by Dr. Gladstone, but in 1940 published by Petrie as '1½% of antimony in the whole metal' (*Wisdom of the Egyptians*, 1940, pp. 91, 94).

was not known until a comparatively late date. Also it is a difficult ore from which to extract gold. And finally the gold telluride from Transylvania does not contain antimony.[1]

There are written records of gold being brought to Egypt from the south in the Twelfth Dynasty, but no record can be found of gold having been brought to Egypt from the North before the Nineteenth Dynasty. The places mentioned as sources of gold are as follows:

South: Twelfth Dynasty[2] (Koptos; Nubia); Eighteenth Dynasty[3] (Highlands; Karoy; Koptos; Kush; Punt; South Countries); Nineteenth Dynasty[4] (Akita; God's Land; Karoy; Punt); Twentieth Dynasty[5] (Edfu; Emu; Koptos; Kush; Malachite Country; Negro Lands; Ombos).

North: Nineteenth Dynasty (Libya)[6]; Twentieth Dynasty (Asia)[7]; Twenty-second Dynasty (Khenthennofer).[8]

One of the oldest known maps in the world, now in the Turin Museum, is one on papyrus showing a gold-bearing region in the eastern desert of Egypt. This dates from the reign of Seti I (Nineteenth Dynasty; 1313 B.C. to 1292 B.C.).

Gold Mining.

The ancient method of treating gold ores to obtain the metal was very simple. In the case of alluvial gold, the sand or gravel was merely washed with running water, which carried away the lighter material, leaving the heavier gold particles behind, which were collected and fused into small ingots: occasionally small nuggets of gold were also found and two such nuggets were discovered at El Kab in a tomb of the archaic period.[9]

The Egyptian method of extracting gold from the veins in quartz rock is described by Agatharchides, a Greek writer of the second century B.C., who visited the mines and wrote a detailed account of what he had seen. Although the original work has been lost, the description of the gold mines has fortunately been preserved by Diodorus, who quotes it in full.[10] The rock was first cracked and broken by means of fire and then attacked by hammers and picks. The

[1] J. W. Mellor, *Inorganic and Theoretical Chemistry*, XI, p. 1.
[2] J. H. Breasted, *op. cit.*, I, 520, 521.
[3] II, 263, 373, 502, 514, 522, 526, 652, 774, 889.
[4] III, 37, 116, 274, 285, 286.
[5] IV, 30, 33, 34, 228, 409.
[6] III, 584.
[7] IV, 26.
[8] IV, 770.
[9] J. E. Quibell, *El Kab*, p. 7.
[10] III: 1.

broken rock was then carried outside the mine, where it was crushed in large stone mortars to the size of peas and afterwards ground to fine powder in hand mills, this powder being washed with water on a sloping surface in order to separate the metal, which probably finally was fused into small ingots. Many of the old stone grinding mills, and remains of the stone tables for treating the pulverised ore to extract the gold, are still to be seen at the ancient mines.

The results of the analyses of twenty different specimens of gold from ancient Egyptian objects will be found in the Appendix,[1] from which it will be seen that the percentage of gold varies from 72.1 (17 carats) to 99.8 (23.5 carats). Mrs. Ransome Williams gives the fineness of the better quality of ancient Egyptian gold jewellery as ranging from 70.8 per cent (17 carats) to 91.7 per cent (22 carats), but mentions specimens as low as 13, 12 and 9 carats respectively.[2]

Thomas gives the results of the assay of five samples of gold from modern Egyptian mines as ranging from 84.0 per cent of gold (20 carats) to 90.3 per cent (21.5 carats),[3] assuming silver to have been the only impurity. A very considerable number of other results taken from the actual working on a large scale of the six principal modern Egyptian mines varied from 76.0 per cent (18.2 carats) to 86.0 per cent (20.6 carats),[4] again assuming silver to be the only impurity.

Gold in the form of large rings, believed to have been alluvial gold from Abyssinia, received at the Egyptian Government Assay Office was about 91.7 per cent (22 carats) pure, and gold bars received for assay from a mine in the eastern desert were about 83.3 per cent (20 carats).

The principal impurity, and sometimes the only one of importance, in Egyptian gold is silver, with occasionally a little copper and a trace of iron.

Gold Refining

Judging from the results of the analyses of ancient Egyptian gold objects,[5] gold was not purified or refined in any way until about the

[1] See p. 545.
[2] C. R. Williams, *Gold and Silver Jewelry and Related Objects*, p. 25.
[3] E. S. Thomas, *Notes on the Mining Industry of Egypt*, in *Cairo Scientific Journal*, III (1909), p. 112.
[4] Kindly communicated by Mr. R. H. Greaves, formerly Controller, Mines and Quarries Department, Egypt.
[5] See p. 545.

Persian period (525 to 332 B.C.), though the Egyptian records mention fine gold; gold of two times and gold of three times in the Twentieth Dynasty (1200 to 1090 B.C.)[1] and fine gold in the Twenty-first Dynasty (1090 to 945 B.C.),[2] which suggest refining. In the second century B.C. Agatharchides describes a method of refining gold practised in Egypt by heating it with lead, salt, tin and barley bran,[3] no provision however being made for the recovery of the silver, which must have been lost. Towards the close of the Eighteenth Dynasty and onwards gold was sometimes debased by the addition of copper, and Petrie states that many of the finger rings of the late Eighteenth Dynasty ' almost verge into copper,'[4] A ring of this nature, of late but uncertain date, analysed by me consisted of approximately 75 per cent of copper and 25 per cent of gold.

Gold Working

That the Egyptian goldsmiths were craftsmen of a very high degree of skill is shown by certain of their products that have been preserved, for instance the gold work of the four bracelets from Abydos (First Dynasty)[5]; the gold foil and the gold brads or rivets (Third Dynasty) from Saqqara[6]; the gold work from the tomb of Hetepheres (Fourth Dynasty)[7]; the gold head of the hawk from Hierakonpolis (Sixth Dynasty)[8]; the gold work found at Dahshur and Lahun (Twelfth Dynasty)[9, 10, 11] and that from the tomb of Tut-ankhamun (Eighteenth Dynasty).[12, 13] Some of their operations are depicted on the walls of certain tombs, for example in the tomb of Ti at Saqqara (Fifth Dynasty)[14]; in the tomb of Mera at Saqqara (Sixth Dynasty);

[1] J. H. Breasted, *op. cit.*, IV, 228, 231, 245, 285, 327, 331, 343, 385, 386, 389, 408, 491, 498.

[2] IV, 610.

[3] Quoted by Diodorus, III: 1.

[4] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, p. 94.

[5] W. M. F. Petrie, *The Royal Tombs*, II, pp. 16–9; Pl. I.

[6] C. M. Firth and J. E. Quibell, *The Step Pyramid*, App. I, pp. 140–1.

[7] G. A. Reisner, in *Bull. of the Museum of Fine Arts, Boston*, XXV (1927), special supplement; XXVI (1928); XXX (1932).

[8] W. M. F. Petrie and J. E. Quibell, *Hierakonpolis*, I, p. 11; J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 27.

[9] J. de Morgan, *Fouilles à Dahchour*, mars-juin, 1894 and 1894–5.

[10] G. Brunton, *Lahun I, The Treasure.*

[11] A. M. Lythgoe, *The Treasure of Lahun*, in *Bull. Met. Mus. of Art, New York*, II, 1919.

[12] Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I.

[13] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, III.

[14] G. Steindorff, *Das Grab des Ti*, Pl. 134.

in a tomb at Beni Hasan (Twelfth Dynasty)[1] and in the tomb of Rekhmara at Thebes (Eighteenth Dynasty).[2]

Even as early as the Fourth Dynasty the ancient goldsmiths were manifestly able to manipulate comparatively large amounts of gold at one time, as shown by the gold work on the canopy of Hetepheres, and by the time of the Eighteenth Dynasty they were making solid gold coffins like that of Tut-ankhamun, which is 6 feet 1¾ inch long, weighs approximately 296 pounds Troy (110.4 kilograms) and is engraved inside as well as outside.

Gold was shaped both by hammering and casting (it melts at 1,063° C., or 20° C. lower than copper); it was engraved and embossed; it was used in the form of granules for decorative purposes; it was made into thin sheets for covering furniture, wooden coffins and other objects, for plating copper and silver and for cutting into thin strips to make wire; it was beaten into still thinner leaf for gilding; it was coloured, soldered[3] and burnished, in fact there are few of the modern practices of working gold that were not known and employed in ancient Egypt, many of them at a very early date. The details of the methods used for making jewellery have been studied and described by Mrs. R. Williams,[4] Vernier,[5] and Petrie.[6]

Specimens of sheet gold (foil) measured by me have varied from 0.17 mm. to 0.54 mm. in thickness and the leaf has varied from 0.01 mm. to 0.09 mm. Petrie states that it 'was often about a 5,000th of an inch thick,'[7] or 0.0051 mm. The ancient gold leaf, however, was not nearly as thin as the modern article, which ranges from 0.00008 to 0.0002 mm. in thickness.[8]

When gold foil (i.e. thick sheet gold), which was generally embossed or engraved, was employed for decorating wooden objects, it was put

[1] P. E. Newberry, *Beni Hasan*, I, Pl. XI.

[2] P. E. Newberry, *The Life of Rekhmara*, Pl. XVIII.

[3] Some of the gold 'sequins' from the tomb of Tut-ankhamun have shanks at the back which are soldered on with gold of a slightly lower melting point than that of the sequin. The tubes of both the silver trumpet and the copper or bronze trumpet from the tomb of Tut-ankhamun are soldered with a white solder that appears to be largely silver.

[4] C. R. Williams, (*a*) *op. cit.*, (*b*) *Bull. Met. Museum of Art, New York*, X (1915), pp. 117–9.

[5] E. Vernier, (*a*) *Bijoux et orfèvreries*; (*b*) *La bijouterie et la joaillerie égyptiennes*, in *Bull. de l'Inst. franç. de l'archéol. orient. du Caire*, II, 1907.

[6] W. M. F. Petrie, (*a*) *The Royal Tombs*, II, pp. 17–9; (*b*) *Arts and Crafts of Ancient Egypt*, 1910, pp. 83–96.

[7] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, p. 96.

[8] Sir Ed. Thorpe, *A Dict. of Applied Chemistry*, 1912, III, p. 781.

directly on to the wood and fastened in place with small gold rivets, as for instance the gold foil on the plywood coffin of Third Dynasty date from Saqqara,[1] but when thinner sheet gold was used, the wood was first covered with a layer of special plaster (gesso) to which the gold was attached by means of an adhesive, probably glue. For gilding with the still thinner gold leaf, a similar layer of plaster was used, but the nature of the adhesive is not certain, though Professor Laurie believes that in one case he has found evidence of the use of white of egg for this purpose.[2]

Gold Plating

Both copper and silver were plated with gold. The plating of copper was done in two different ways: one in which thin sheet gold was hammered on to the copper, and the other where thin gold leaf was fastened on with an adhesive, which, in the specimens that have been tested, is soluble in water and is, therefore, probably gum or glue. Examples of the first-named technique are (*a*) two copper rods plated with gold from the First Dynasty[3]; (*b*) copper feathers plated with gold from the Sixth Dynasty[4]; (*c*) a small button seal of about the Sixth Dynasty kindly shown to me by Guy Brunton; (*d*) one ibis amulet (probably two),[5] and several objects, probably bracelets,[6] found by Brunton and dating from the period Seventh to Eighth Dynasty; and (*e*) a gold-plated copper collar from the Twelfth Dynasty. Examples of the second-named technique are the large 'marguerites' which are probably of copper, that were sewn to the linen pall from the tomb of Tut-ankhamun,[7, 8] and probably also the identical-looking 'marguerites' from the so-called 'Tomb of Queen Tiyi.'[9]

As instances of the gold plating of silver may be mentioned the Twenty-second Dynasty pectoral and the dagger blade both cleaned by me[10] and described by Vernier.[11]

[1] C. M. Firth and J. E. Quibell, *op. cit.*, p. 141.

[2] A. P. Laurie, *Methods of Testing Minute Quantities of Material from Pictures and Works of Art*, in *The Analyst*, XVIII (1933), p. 468.

[3] W. M. F. Petrie, *The Royal Tombs*, II, p. 36.

[4] W. M. F. Petrie, *Abydos*, II, p. 32; Pl. XXI.

[5] G. Brunton, *Qau and Badari*, II, p. 12. [6] G. Brunton, *op. cit.*, I, pp. 34, 66.

[7] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 33; Pl. IV.

[8] A. Lucas, *Appendix II*, p. 172, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

[9] Theodore M. Davis, *The Tomb of Queen Tîyi*, p. 40.

[10] A. Lucas, in *Annales du Service*, XXIV (1924), pp. 15–6.

[11] E. Vernier, *Bijoux et orfèvreries*, pp. 240–1, 378–9; Pls. LXIII–IV; LXXVII.

Gold Colouring

One very noticeable feature of ancient gold is its varied colour, which comprises bright yellow, dull yellow, grey and various shades of red, including reddish-brown, light-brick colour, blood colour, dull purple (purple-plum colour) and a very remarkable rose-pink, all, except the last-named, being fortuitous. The bright yellow gold is fairly pure; the dull and tarnished yellow contains small proportions of other metals, such as silver and copper, which where exposed have undergone chemical change. The grey gold contains a large proportion of silver, which on the surface has become converted into chloride of silver, that has darkened in the manner usual with this compound. The reddish-brown colour gives the tests for iron and copper and is evidently due to these metals having become oxidized. In some instances a red or purple colour has proved to be a staining of the gold by organic matter. The rose-pink colour occurs on a number of objects in the Cairo Museum, for example, on a gold 'marguerite' from the so-called 'Tomb of Queen Tiy' (Eighteenth Dynasty), on the diadem from the tomb of Queen Tewosret[1] (Nineteenth Dynasty) and on the earrings of Ramesses XI (Twentieth Dynasty), but more particularly on a number of the gold objects from the tomb of Tut-ankhamun, which latter was reported upon several years ago by me as follows[2]: 'The rose colour can be proved by chemical analysis not to be due to any colloidal modification of the gold, nor to any sort of organic lacquer or varnish, and the gold can be made red-hot without the colour being removed or diminished, but in some instances rather enhanced. The coloured film, however, is so extremely thin, being probably less than one hundred-thousandth of an inch in thickness, that without more material than it is desirable to use, chemical analysis becomes very difficult. A trace of iron is the only metal found so far, and since it is well known that native gold is sometimes reddened by being coated with a translucent film of oxide of iron, it is suggested that the colour in question is probably due to oxide of iron, but in what manner it was produced is not known, as it occurs on both sides of most objects on which it is present. This suggests that the object may have been dipped in a solution of an iron salt and then heated.

[1] Theodore M. Davis, *The Tomb of Siptah: The Monkey Tomb and the Gold Tomb.* Plate without number entitled 'Gold Bracelets and Ornaments of Queen Taousret' on which a rosette (possibly from the diadem) is coloured rose-pink.

[2] A. Lucas, *Appendix II*, p. 174, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

That this colour is intentional is shown by its regular and systematic distribution on certain objects or on certain parts of objects.' The predictions that the rose-pink colour was due to iron and that it had been produced by heating have been proved to be correct by Professor R. W. Wood of The Johns Hopkins University, Baltimore,[1] who has reproduced the colour so exactly that put side by side with the original it cannot be distinguished from it. The colour was made by fusing pure gold with a slight trace of iron.

Electrum

Electrum is an alloy of gold and silver, which may be either natural or artificial, but which originally was natural, that employed in ancient Egypt being probably always natural. These alloys may contain almost any proportion of the two constituents, and when the amount of gold is high the appearance is that of ordinary gold, and when the content of silver is high the colour is silver-white and the metal would pass as silver. Such extremes, however, are not called electrum, the term being limited to an alloy of a pale yellow colour, and it was this that the Greeks termed *electron* and the Romans *electrum*, usually stated to have been so-called from its resemblance in colour to amber, the name for which, as used by Homer and Hesiod, was *electron*, though, since the alloy was probably the earlier known, the reverse seems likely to have been the case.

In the ancient records electrum is stated to have been brought to Egypt from Punt,[2] Emu,[3] the Highlands,[4] the South Countries,[5] from a mine east of Redesia[6] and from the mountains,[7] all places south of Egypt, and there is no reference to its having been obtained from the North, and no evidence whatever that it ever reached Egypt from Pactolus, as stated by Petrie.[8] The division between gold and electrum is entirely arbitrary, and when the alloy contains less than 20 per cent of silver it is here called gold and when it contains 20 per cent or more of silver and is of a light yellow colour it is here called electrum, which accords with Pliny's definition.[9]

[1] R. W. Wood, The Purple Gold of Tut-ankhamûn, in *Journal of Egyptian Archaeology*, XX (1934), pp. 62–5. The specimen of gold coloured by Professor Wood is now in the Cairo Museum.
[2] J. H. Breasted, *op. cit.*, I, 161; II, 272. [3] II, 298, 387.
[4] II, 374, 377. [5] II, 654. [6] III, 403. [7] IV, 28.
[8] W. M. F. Petrie, *Social Life in Ancient Egypt*, p. 164.
[9] XXXIII: 23.

The various specimens of ancient Egyptian electrum of which analyses are recorded[1] show a silver content varying from 20.3 to 29.0 per cent, and some electrum finger rings in the Cairo Museum, that it is not possible to analyse, have approximately the same shade of light yellow as a gold-silver alloy of 15 carats, which corresponds to 37.5 per cent of silver. Rose states[2] that 'nearly white electrum occurs native in a number of localities, and the proportion of silver, according to Phillips,[3] may exceed half the weight of the mixture and certainly reaches 39 per cent.'

From the results of the assay of modern Egyptian gold already quoted, there cannot be any doubt that electrum is found in the country and it seems highly probable that the supply sufficed to meet the local needs. The reason that electrum is not usually recognized as occurring in Egypt is that the modern gold prospector and gold miner consider it to be merely a poor quality of gold, since it has no value at the present day except as a source of gold and silver.

Electrum is harder than gold and, therefore, is the better fitted of the two for the wear and tear incidental to its use for jewellery, and this fact may have influenced its use in ancient Egypt.

Electrum was employed principally for jewellery and its use can be traced back to early dynastic times; it was used as late as the Twenty-first and Twenty-second Dynasties for jewellery and for finger and toe stalls.

Iron

Though compounds of iron are exceedingly abundant in nature, metallic iron is rare and usually occurs in comparatively small amount. This native iron is of two different origins and two different kinds, (*a*) terrestrial, occurring generally as minute grains in certain volcanic rocks, but also, though very exceptionally, in large masses, probably only one such occurrence (in Greenland) being known; and (*b*) celestial, this being dust or fragments from meteorites consisting of, or containing, iron. Meteoric iron possesses one very useful distinguishing characteristic, namely, that it almost invariably contains the metal nickel, the proportion varying from about 5 to about 26 per cent,[4] but usually being about 7 or 8 per cent, whereas terrestrial iron and iron ores rarely contain nickel and, when present, it is only in very small amount.

[1] See p. 546. [2] Sir T. K. Rose, *The Metallurgy of Gold*, 1915, p. 84.
[3] *Gold and Silver*, 1867, p. 2. [4] T. A. Rickard, *Man and Metals*, II, p. 846.

Iron minerals are very plentiful in Egypt and at a very early date (predynastic times) an ore of iron (haematite) was fashioned into beads, amulets and small ornaments[1] and certain compounds of iron, namely, ochres, siennas and umbers, but more particularly red and yellow ochres, were used as pigments.[2] The ores are found chiefly in the eastern desert and in Sinai[3, 4] and the ochres principally near Aswan[5] and in the oases of the western desert.[6]

There are few subjects that are more disputed than that of the date when iron first came into general use in Egypt. Just as some wonderful and mysterious hardened copper or bronze (the composition and secret of the preparation of which have been lost) has been postulated to account for the early Egyptian work in hard stone, so it is often claimed that not only iron but steel must have been known and employed for this purpose.[7, 8, 9] The fact that a few specimens of iron of early date have been found has been used to support this argument, and it is stated that it is only on account of the easily oxidizable nature of iron that tools and other objects of this metal have not been discovered more frequently. Iron, however, although it does oxidize readily in damp soil, particularly if salt is present, is quite stable under the ordinary conditions that prevail in rock-cut and other tombs in Egypt into which water has not penetrated, and the fact that some few specimens of iron have survived is proof that had there been other examples under similar conditions these too would have lasted. It should not be forgotten also that iron when it oxidizes does not disappear, but is converted into a compound that is not only permanent but which, on account of its reddish colour and of its greater volume than that of the original metal, should not escape observation.

Those who believe that iron tools must have been employed for the early Egyptian work in hard stone attach considerable importance to a piece of iron found at the great pyramid of Giza,[10] and see in this

[1] See p. 452. [2] See pp. 397, 399.

[3] W. F. Hume, *The Distribution of Iron Ores in Egypt: Geology of Egypt*, II, Part III, pp. 848–52.

[4] W. F. Hume, *Explan. Notes for the Geol. Map of Egypt*, pp. 38–9.

[5] W. F. Hume, *Geology of Egypt*, II, Part III, 1937, p. 851.

[6] L. Nassim, *Minerals of Economic Interest in the Deserts of Egypt*, in *Report of Congrès intern. de géog., Le Caire, 1925*, III (1926), pp. 164–5.

[7] Sir R. Hadfield, *Sinhalese Iron and Steel of Ancient Origin*, in *Journal of the Iron and Steel Institute*, 1912, pp. 134–86, 149, 150, 169, 182.

[8] J. de Morgan, *Recherches sur les origines de l'Égypte*, pp. 213, 214.

[9] H. Garland and C. O. Bannister, *Ancient Egyptian Metallurgy*, pp. 85–112.

[10] See p. 270.

a proof that iron tools were used in its construction, in support of which the reference in Herodotus to iron tools in connexion with the pyramid is quoted.[1] By far the greater part of the stone of the pyramid, however, is not hard and there would be no great difficulty in working it without iron tools, and the specimen of iron found is not a tool and does not appear to be part of a tool of any sort, and it is significant that the earliest iron objects are chiefly weapons and amulets and not tools. Herodotus was not discussing the tools employed in the construction of the pyramid, but the cost of the pyramid, and incidentally includes that of the tools, which he assumes to have been of iron because iron tools for stone working were familiar to him. Thus he says '. . . how much must needs have been expended on the iron with which they worked . . .' This same writer also says that the Ethiopians marching in the army of Xerxes carried short arrows 'pointed not with iron but with a sharpened stone.'[2]

The specimens of early iron found in Egypt may now be described. The earliest are two lots of small tubular beads (one lot of seven and one lot of two) of predynastic date found by Wainwright at Gerzeh.[3] When found, the beads were entirely in the condition of oxide, but Professor Gowland, who analysed them, stated that originally they had been metallic iron and had been made by bending into tubular shape a thin strip of metal. These beads have since been analysed by Professor Desch and found to contain 7.5 per cent of nickel,[4] thus proving that the iron of which they were made was of meteoric origin. The next specimen in date order is that already referred to from the pyramid of Cheops which was found in the stonework on the outside.[5] Although the statements of the finder (Mr. J. R. Hill) and others, who examined the spot at the time, are very definite and precise and not lightly to be disregarded, it seems more probable, since the iron has been proved not to be meteoric,[6] that it is of recent date and that it had been lost down a crack in the stone facing of the pyramid when this was being removed for use as building material in modern times, long before

[1] II: 125.
[2] VII: 69.
[3] G. A. Wainwright, in *The Labyrinth, Gerzeh and Mazghuneh*, W. M. F. Petrie and others, pp. 15–6.
[4] C. H. Desch, *Report on the Metallurgical Examination of Specimens for the Sumerian Committee of the Brit. Assn.*, in *Rept. of the Brit. Assn.*, 1928.
[5] H. Vyse, *The Pyramids of Gizeh*, I, pp. 275–6.
[6] C. Hawkes, Early Iron in Egypt, *Antiquity*, X (1936), p. 356.

Vyse's work.[1] The next specimen is iron oxide of Fourth Dynasty date found by Reisner in the Mycerinus Valley Temple at Giza, which originally had been a small piece of iron forming part of a 'magical set.'[2] After this are several pieces of a pickaxe found by Maspero at Abusir stated to be possibly of Sixth Dynasty date,[3] the finder himself not being certain about the matter, and the correctness of the dating, therefore, may reasonably be questioned. Then comes a mass of iron rust found by Petrie with copper adzes of Sixth Dynasty type,[4] of which the finder says 'this is absolutely certain and not open to any doubts.'[5] When tested chemically, this was found not to contain nickel and hence it is not meteoric.[6] There is no proof that it was a tool or implement of any kind and what it was and how it came to be placed in the foundations of a temple at Abydos will probably always remain a mystery; but it may have been a piece of iron produced accidentally that could not be used because the art of shaping it while red-hot had not then been discovered. Then comes a tiny *Pesesh-Kef* amulet having a silver head and an iron blade from the Eleventh Dynasty at Deir el Bahari, the blade of which has been analysed by Desch and found to contain 10 per cent of nickel and therefore to be of meteoric origin.[7]

After that comes an iron spear-head from Nubia, which is attributed to the Twelfth Dynasty,[8] but that iron should be known and employed in an out-of-the-way place in Nubia in the form of a large weapon for common use more than four hundred years before the time when the king of Egypt (Tut-ankhamun) possessed only one small iron dagger, and more than 1,000 years before iron became common in Egypt, is so extraordinary that more evidence than that adduced is necessary before the date assigned to this object can be accepted, especially as it is practically identical with spear-heads used until not many years ago in the same locality. Wainwright points out that it is not tanged, as

[1] At one time I thought that this iron must be contemporaneous with the pyramid, but on reconsidering the evidence in the light of the recently ascertained fact that the iron is not meteoric, I am now of opinion that the balance of evidence is against its being ancient.

[2] Dows Dunham and W. J. Young, An Occurrence of Iron in the Fourth Dynasty, *Journal of Egyptian Archaeology*, 28 (1942), pp. 57–8.

[3] G. Maspero, *Guide au Musée du Boulaq*, 1883, p. 296.

[4] W. M. F. Petrie, *Abydos*, II, pp. 32–3.

[5] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, p. 104.

[6] C. Hawkes, *op. cit.*, pp. 356–7.

[7] G. Brunton, *Annales du Service*, XXXV (1935), p. 214.

[8] D. Randall-MacIver and C. L. Woolley, *Buhen*, pp. 193, 211; Pl. 88.

would be normal for the Twelfth Dynasty, but socketed.[1] Then comes part of a chisel and part of a hoe stated to be of the Seventeenth Dynasty,[2] but of which nothing precise is known. From the tomb of Tut-ankhamun (late Eighteenth Dynasty) there are several iron objects,[3] namely, a dagger, a miniature head-rest, an amuletic eye set in a gold bracelet and sixteen implements having full-sized handles of some coniferous wood, but with blades so small and thin that they could not even have been used by the boy king to play with, the total weight of all the blades being only about four grams, and Wainwright has shown that these were probably magical implements for the ritual ceremony of 'Opening the Mouth' of the mummy of the dead pharaoh.'[4] Whether these are of meteoric iron, as theoretically they should be, is not known, since an analysis has not yet been made. The head-rest, which is a typical Egyptian object, and therefore probably made in the country, has been badly welded and shows several imperfections due either to lack of experience in working iron or to the absence of a sufficiently high temperature: the metal, too, is of a different colour and quality from that of the dagger, eye and miniature implements, as it has a dark, smooth surface and has not rusted. It weighs approximately 47 grams (rather more than an ounce and a half).

From the time of Tut-ankhamun onwards, there is a gradual increase in the number of iron objects found, until the Twenty-fifth Dynasty (712 to 663 B.C.), of which date there is a group of iron tools,[5] after which iron becomes much more common and at Naucratis and Defenneh in about the Twenty-sixth Dynasty (663 to 525 B.C.) it was as common as bronze or even commoner and was being smelted in the country.[6] In 255–254 B.C. iron tools were being supplied to quarrymen[7] and a papyrus of Ptolemaic date from the Fayum 'gives interesting details about tools and other objects made of iron.'[8]

[1] G. A. Wainwright, The Coming of Iron, *Antiquity*, X (1936), pp. 5–24.

[2] G. Maspero, *op. cit.*, p. 296.

[3] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, pp. 109, 122, 135; Pls. LXXVII, LXXXII, LXXXVII; III, pp. 89–90; Pl. XXVII.

[4] G. A. Wainwright, *Iron in Egypt*, in *Journ. Egyptian Archaeology*, XVIII (1932), p. 7.

[5] W. M. F. Petrie, *Six Temples at Thebes*, pp. 18–9.

[6] W. M. F. Petrie, *Naukratis*, I, p. 39; *Nebesheh and Defenneh*, p. 77.

[7] J. P. Mahaffy, *The Flinders Petrie Papyri*, II, p. 7; C. C. Edgar, Four Petrie Papyri Revised, *Studies Presented to F. Ll. Griffith*, pp. 211–2.

[8] C. C. Edgar, *Papyri Zenon IV*, No. 59782.

It is evident, therefore, that on at least one occasion at a very early date a very small quantity of meteoric iron was found in Egypt and made into beads, but there was no knowledge of what iron was or how to extract it from its ores and possibly not even the knowledge that this particular piece of material had fallen from the sky, though at a later date other finds of meteoric iron may have been recognized as such and may have been used for making small objects for ritual purposes, as suggested by Wainwright.[1] With several alleged exceptions (some of which are almost certainly of much later date than that assigned to them) this condition of things continued until the end of the Eighteenth Dynasty, when an iron dagger and sufficient iron to make sixteen tiny blades, a miniature head-rest and a small amulet came into the possession of Tut-ankhamun, almost certainly having been presented to him by one of the kings of western Asia, the home of iron-working. Iron must have been rare in Palestine and Syria also until at least the end of the Eighteenth Dynasty, since among the tribute levied by Egypt on the peoples she conquered only one mention of iron can be traced, namely, 'vessels of iron' received by Tuthmosis III from Tinay, an unknown country to the north of Egypt.[2] Also, Tusratta, king of Mitanni, presented to Amenophis III a 'dagger whose blade is of steel . . .'; 'one *mitten* of iron, overlaid with gold'; two 'hand-rings of iron, overlaid with gold'; 'one dagger, whose blade is of iron, whose shaft is trimmed with lapis lazuli . . .'; 'one dagger whose blade is of steel . . .',[3] and the same king presented to Amenophis IV 'Ten rings of iron, overlaid with gold . . .'[3]

In the tomb of Sheshonq (Twenty-second Dynasty) discovered at Tanis by Montet in 1939 there was a sacred eye of iron mounted in a gold bracelet and a very clumsily-made miniature head-rest of badly-prepared iron, which seem to prove that as late as the Twenty-second Dynasty iron smelting and iron working were still in their infancy in Egypt.

The earliest date for which at present there is evidence of iron ores having been worked for metal in Egypt is provided by Petrie's discovery of evidence of smelting at Naucratis (sixth century B.C.)[4] in the north-west of the Delta, but where the ore (specular iron ore) came

[1] G. A. Wainwright, in *Journ. Egyptian Archaeology*, XVIII (1932), pp. 3–15.
[2] J. H. Breasted, *op. cit.*, II, 557.
[3] S. A. B. Mercer, *The Tell-El-Amarna Tablets*, 1939, Vol. I, pp. 81, 83, 85, 87, 137.
[4] W. M. F. Petrie, *Naukratis*, I, p. 39.

from is not known. Iron ores, however, have been worked anciently in the eastern desert[1, 2, 3] and near Aswan,[3, 4] in the former locality possibly by the Romans.

The principal reason that iron became known to man so much later than copper, although iron ores are far more abundant than copper ores and almost as easy to smelt, is probably due to the fact that copper can be shaped by cold-hammering, whereas iron must be hammered hot, and doubtless impure metallic iron has been produced accidentally many times and rejected as useless long before someone tried hammering it while still hot and found that under such conditions it was almost as malleable as copper. Another difficulty was that hammering red-hot iron was impossible with hammers without handles, which apparently were the only kind known to the Egyptians until late.

Iron ores can be reduced to metal, in the presence of carbon, at a temperature not exceeding 500° C.,[5] and the iron becomes a pasty mass that can be worked at from 800° C. to 900° C.,[6] but it does not become liquid enough to be poured for casting until about 1,530° C., which is much too high a temperature to have been obtained anciently, and furnace construction only advanced sufficiently for this to be done in the fourteenth century, only a few hundred years ago. Casting, therefore, was impossible and in this respect iron was inferior to copper and bronze and, since iron was also more difficult to work, because less malleable and, since it was little, if any, harder than copper and bronze, the new metal was at first not so satisfactory as the old ones.

The early wrought iron, on account of the way it was made, would contain little or no carbon (less than 0.2 per cent) and such iron is not hardened but softened if heated and suddenly cooled; but with an increase in the proportion of carbon present, this property of being hardened is acquired, and it is this higher proportion of carbon (from 0.2 per cent to not more than 2.0 per cent), with the resultant virtue

[1] T. Barron and W. F. Hume, *Topog. and Geol. of the Eastern Desert of Egypt, Central Portion*, pp. 44, 51, 86, 221, 222, 225, 239, 257.

[2] W. F. Hume, *The Distribution of Iron Ores in Egypt*, p. 8.

[3] J. de Morgan, *Cat. des monuments et inscriptions de l'Égypte antique*, I, pp. 139–41.

[4] P. Bovier-Lapierre, *Note sur le traitement métallurgique du fer aux environs d'Assouan*, in *Annales du Service*, XVII (1917), pp. 272–3.

[5] H. Louis, *Iron Manufacture and Heat Generation*, in *Nature*, 123 (1929), p. 762.

[6] T. A. Rickard, *Man and Metals*, I, p. 144. See also H. H. Coghlan, Prehistoric Iron prior to the Dispersion of the Hittite Empire, *Man*, No. 59 (1941). Also No. 63 (1941).

it imparts, that constitutes the difference between wrought iron and steel, steel being iron containing small proportions of added carbon (the carbon content of the ordinary modern product ranging from about 0.7 to 1.7 per cent) that imparts to it the property mentioned, and iron only became a thoroughly serviceable metal for weapons and tools after the discovery of the method (for a long time purely empirical and without any understanding of the underlying principle) of adding a little extra carbon (carburising, as it is termed), so that when heated and suddenly cooled (quenched) it became hardened.[1] This result may be brought about by allowing the iron to remain in contact with carbon at a high temperature for some time, when a certain small proportion of the carbon is absorbed by the iron, the amount depending upon the length of time the two are kept in contact, being greatest at the surface and gradually lessening towards the centre. At one time a process (called the cementation process) employed for making steel, which is still used to some extent, was to pack the iron in charcoal and heat it strongly for several days. Such a considered method, however, is a comparatively late invention, but a similar result can be brought about by the frequent heating and reheating of iron in a charcoal fire, and this must have been the method practised anciently, probably an outcome of the hammering and reheating that were necessary to free the lumps of iron as at first produced, which would have contained air-holes and in consequence would have been spongy, from adherent slag and other impurities; to consolidate it and to shape it.

Since the production of iron from its ores was not an Egyptian discovery, it is most unlikely that the subsequent metallurgical treatment should have been Egyptian, and it seems highly probable, therefore, that blacksmiths from Asia were introduced into the country in order to teach the Egyptians how to smelt and treat the new metal.

A copper-iron alloy of early dynastic date was found at Abydos.[2]

LEAD

Although never very extensively employed in ancient Egypt, lead was among the earliest metals known, since it dates from predynastic times.[3] The reason for this early knowledge of lead was doubtless owing to the facts, first, that lead ores occur in Egypt, one of them (galena) being

[1] Steel may also be produced directly by smelting certain kinds of iron ore (H. Louis, *op. cit.*, p. 762).

[2] E. Amélineau, *Fouilles d'Abydos*, 1899, p. 275.

[3] W. M. F. Petrie, *Prehistoric Egypt*, p. 27.

very metallic-looking and, therefore, likely to attract attention, and second, that the metal is very easily obtained from the ore.

The principal locality in Egypt where lead ores are found is at Gebel Rosas,[1, 2] which is situated about 70 miles south of Quseir and a few miles inland from the Red Sea, but there are deposits in other places, namely, at Ranga on the Red Sea coast[1, 2]; in the Safaga district near the Red Sea,[1, 2] where about two miles south of Safaga Bay there is an ancient working covering the whole side of a limestone hill[3]; associated with the Um Semiuki copper ore[4] and near Aswan.[1, 2] Other deposits of lead ore have recently been found at Zug el Bahr and Um Reig on the coast south of Quseir. During the four years 1912 to 1915 inclusive when the Gebel Rosas mine was being worked it produced more than 18,000 tons of ore, in the form of mixed carbonate and sulphide of lead associated with carbonate of zinc.[1] The ore contains the equivalent of from 25 to 55 per cent of metallic lead, a very small proportion of silver and also a trace of gold.[5] Hall states that ' analyses show up to 58 per cent lead and 37 per cent zinc.'[6]

The principal ore of lead is the sulphide (galena), which was used in Egypt as an eye-paint from as early as Badarian times to as late as the Coptic period.[7]

The production of metallic lead from its ores is one of the simplest of all metallurgical operations and consists essentially in merely roasting the ore, which is now done in special furnaces, though doubtless in ancient times by simply heaping the ore on top of the fuel on the ground or in a shallow pit, the fused metal, which melts at 327° C. (or less than one-third the temperature required to melt gold) running out at the bottom of the heap.

Lead was used for many purposes, including small human and animal figures[8, 9]; sinkers for fishing nets[9]; rings[9]; beads[10];

[1] Mines and Quarries Department, *Report on the Mineral Industry of Egypt*, 1922, p. 24.

[2] W. F. Hume, *Explan. Notes to the Geol. Map of Egypt*, pp. 38–9: *Geology of Egypt*, Vol. II, Part III, p. 856.

[3] C. J. Alford, *Gold Mining in Egypt*, in *Journ. Inst. Mining and Metallurgy*, 1901, p. 13.

[4] See p. 236.

[5] Kindly communicated by Mr. R. H. Greaves, formerly Controller, Mines and Quarries Dept.

[6] T. C. F. Hall, *Lead Ores*, p. 63.

[7] See p. 99.

[8] W. M. F. Petrie, *Prehistoric Egypt*, p. 27.

[9] W. M. F. Petrie, *Objects of Daily Use*, p. 49.

[10] J. E. Quibell and A. G. K. Hayter, *Excavations at Saqqara, Teti Pyramid, North Side*, p. 7. Also one of First Intermediate period found by Brunton.

ornaments[1]; model dishes and trays[1]; plugs[2]; for adding to bronze (more than 20 per cent having sometimes been used, which must have lowered the melting point of the bronze considerably, and thus made casting easier); occasionally for vessels[3]; for the headdresses of gods, a group of twenty of which of unknown date and origin are in the Cairo Museum[4]; and sometimes for filling bronze weights and as a core for bronze statuettes. Sulphide of lead (galena), as already stated,[5] was extensively employed as an eye-paint; a compound of lead and antimony was used for producing a yellow colour in glass[6] and three examples are known of the use of oxides of lead as pigments, one being red oxide (red lead) in a mural painting of Graeco-Roman date,[7] the second being red lead on a scribe's palette (undated, but most probably of a late period)[8] and the third being yellow oxide (massicot) on a scribe's or artist's palette dating from about 400 B.C.[9]

There can be little doubt that most, if not all, the lead and galena used in Egypt until about the Eighteenth Dynasty was of local origin and there is no evidence that it was 'probably brought from Syria'[10] until after the Egyptian conquests in Asia, when, according to the translation of the ancient records, it was imported from Zahi[11]; Retenu[12] and Isy,[13] the latter not being Cyprus, as often stated, where lead ores do not occur, but, as shown by Wainwright,[14] a country on the northern coast of Syria.

PLATINUM

Platinum is found only in the metallic state and never pure, but always associated with other metals, principally the closely related ones, iridium, palladium, osmium, rhodium and ruthenium, but also frequently with gold.

Only one occurrence of the intentional use of platinum in ancient Egypt is known, namely a narrow strip inlaid in a metal case of late

[1] W. M. F. Petrie, *Objects of Daily Use*, p. 49.
[2] L. Borchardt, *Das Grabdenkmal des Königs Sahu-Re*, I, pp. 76–7; Fig. 102.
[3] E. A. Gardner, *Naukratis*, II, p. 29. [4] Nos. J. 31589 to 31608.
[5] See p. 99. [6] See p. 219. [7] See p. 399.
[8] J. Barthoux, *Les fards, pommades et couleurs dans l'antiquité*, in *Congrès internat. de Géog. Le Caire, avril, 1925*, IV (1926), pp. 257–8.
[9] A. P. Laurie, *Ancient Pigments and their Identification in Works of Art*, in *Archaeologia*, LXIV (1913), pp. 318–9.
[10] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, p. 103.
[11] J. H. Breasted, *op. cit.*, II, 460, 462. [12] II, 471, 491, 509. [13] II, 494, 521.
[14] G. A. Wainwright, in *Klio, Beitrage zur alten Geschichte*, 1913.

date, which Berthelot examined and found to be 'd'un alliage complexe renfermant plusiers des métaux de la mine de platine sans préjudice d'un peu d'or.'[1] Several gold objects of Twelfth Dynasty date in the Cairo Museum show numerous silver-white specks that I have tested, as far as was possible without injuring the objects, and found to be platinum or one of the platinum group of metals, probably chiefly platinum. Petrie has reported in gold objects of this same dynasty similar hard, white specks, which he calls osmiridium[2] (a natural alloy of osmium and iridium), though no evidence is given for this and it is much more likely that they are largely platinum. Maspero states that certain Egyptian gold jewellery of the Eighteenth Dynasty contained platinum[3] and Mrs. R. Williams records similar particles in a number of instances in ancient Egyptian gold objects.[4]

Platinum has never been reported as occurring in modern Egyptian gold, so far as is known, but it does occur as a trace in the nickel ore from St. John's Island in the Red Sea[5] and has been found in gold from the Sennar province of the Sudan[6] and it occurs, and was being worked on a small scale a few years ago, in western Abyssinia.[7]

Silver

Silver is found in nature in two conditions, namely, as metal and in the non-metallic state.

Native silver, which is practically pure, occurs only in small quantity, generally in the crystalline form, as needles, filaments, network, or arborescent shapes, though also, but more rarely, massive in nuggets and thin plates. Silver also occurs in practically all gold, sometimes in considerable proportion.[8]

[1] Berthelot, *Sur les métaux égyptiens*, in *Monuments et Mémoires Piot*, VII (1900), p. 132. Petrie mentions platinum also 'as an inlay in an unfinished bronze base of a statuette of Amenardas, XXVth dynasty, in the hands of a dealer in Cairo,' but no evidence is given that this was identified by chemical analysis. (Petrie, *Wisdom of the Egyptians*, 1940, p. 91.)

[2] W. M. F. Petrie, *The Metals in Egypt*, in *Ancient Egypt*, 1915, p. 23: W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 66.

[3] G. Maspero, *The Dawn of Civilization*, 1901, p. 493.

[4] C. R. Williams, *Gold and Silver Jewelry and Related Objects*, p. 27.

[5] F. W. Moon, *Prel. Geog. Rept. on St. John's Island*, p. 16.

[6] F. Cailliaud, *Voyage à Méroé au Fleuve Blanc*, XII (1826), p. 19.

[7] Kindly communicated by Mr. A. D. Home, District Commissioner, Gallabat.

[8] See p. 257, note 1. Sometimes irregularly-distributed patches of gold occur in ancient Egyptian silver objects, examples of which were found in the tomb of Tut-ankhamun (Howard Carter, *The Tomb of Tut-ankh-Amen*, III, Appendix II; A. Lucas, p 175).

The principal ores of silver are silver sulphide, either alone or associated with sulphides of antimony or arsenic, and silver chloride. These, however, yield only about one-third of the world's supply of silver, the remaining two-thirds being obtained, not from silver ores proper, but from what are primarily lead, zinc and copper ores containing a very small proportion of silver (usually of the order of from 0.01 to 0.1 per cent), which may, therefore, be considered as low-grade silver ores.

So far as is known, neither native silver nor silver ores proper occur in Egypt, though all Egyptian gold contains silver, the proportion in that from the modern mines varying from 9.7 per cent to 24.0 per cent,[1] and in ancient Egyptian objects of gold and electrum that have been analysed the proportion of silver has varied from probably a trace (this particular specimen having almost certainly been refined) to as much as 29 per cent,[2] though there is no proof that the metal of all these was of Egyptian origin. Silver also occurs in very small amount in both the local lead ore[3] and in the nickel ore.[4] In an Egyptian lead net-sinker, dating from about 1400 B.C., probably made from local lead, there was 0.03 per cent of silver,[5] and 0.01 per cent in some galena from Gebel Jasus.[6]

Silver objects have been found in Egypt from as early as the predynastic period,[7] but they were very rare until about the Eighteenth Dynasty, when silver began to be a little more plentiful, though it was not until much later that it became fairly common. For example, in the Fourth Dynasty the objects from the tomb of Queen Hetepheres[8] may show that silver was then rarer and more precious than gold, since gold was employed lavishly to ornament the furniture, as also in the form of small dishes, a drinking cup, and razors, whereas the only silver found consisted of twenty anklets (inlaid with turquoise,[9] lapis lazuli and carnelian), which, although having an appearance of solidity, because they are rounded on the outside, are only shells of very thin

[1] See p. 262. [2] See pp. 545–6. [3] See p. 276.

[4] F. W. Moon, *op. cit.*, p. 16.

[5] J. Newton Friend, *The Silver Contents of Specimens of Ancient and Mediæval Lead*, in *Journal, Institute of Metals*, XLI (1929), p. 106.

[6] C. J. Alford, *Gold Mining in Egypt*, in *Journ. Inst. Mining and Metallurgy*, 1901, p. 13.

[7] W. M. F. Petrie, *Prehistoric Egypt*, pp. 27, 43.

[8] G. A. Reisner, *The Tomb of Queen Hetep-heres*, in *Bull. Mus. Fine Arts, Boston*, XXV (1927), special number.

[9] This was originally described as malachite by Dr. Reisner, who, however, later accepted my identification of turquoise.

metal, and a small amount of silver leaf on a head-rest. This, however, was a secondary burial and silver objects may have been stolen from the original tomb. Even in the tomb of Tut-ankhamun, some 1,500 years later, there were only a few silver objects, though others may have been stolen, the two largest being a trumpet and a vase in the shape of a pomegranate. From the Twenty-first Dynasty a silver coffin and nine silver vessels, one very large, were found at Tanis and from the Twenty-second a silver coffin and four small silver canopic coffins also from Tanis were found in 1939, all of which are in the Cairo Museum.[1]

Petrie states that the silver employed in the predynastic period 'was obtained probably from Syria'[2] (to which cause he attributes its scarcity[2, 3]) and again that it 'could only be got by mining in North Syria,'[4] but there is no evidence whatever for this, and the principal source of supply was almost certainly local until after the Egyptian conquests in Asia during the Eighteenth Dynasty. The Twelfth Dynasty silver objects and ingots found at Tôd in Upper Egypt[5] were probably presents from Asia. The ancient records are silent as to where silver came from until the Eighteenth Dynasty, when it is stated to have been received from Assur,[6] Kheta,[7] Naharin,[8] Retenu,[9] Senzar[10] and Zahi,[11] all countries in Asia, and in the Nineteenth Dynasty it came from God's Land[12] (here manifestly from the context a country to the North of Egypt), Kheta[13] and Naharin,[14] again all Asiatic countries, but also from Libya,[15] a country to the north-west of Egypt.

As already stated, neither native silver nor silver ores proper occur in Egypt, though silver is found in very small proportion in both the local lead ore and the local nickel ore. Since, therefore, there was no native silver and no ores that could be treated to obtain the metal, and since there is no evidence and very little probability that the Egyptians of predynastic and early dynastic times had the necessary metallurgical

[1] P. Montet, Découverte d'une nécropole royale à Tanis, *Annales du Service*, XXXIX (1939), pp. 529–39; G. Brunton, Some Notes on the Burial of Shashanq Heqa-Kheper-Re, *Annales du Service*, XXXIX (1939), pp. 541–7.

[2] W. M. F. Petrie, *Prehistoric Egypt*, p. 27.

[3] W. M. F. Petrie, *Social Life in Ancient Egypt*, p. 5.

[4] W. M. F. Petrie, *The Metals in Egypt*, in *Ancient Egypt*, 1915, p. 16.

[5] F. B. R., *Tôd (1934 à 1936). Fouilles de l'Inst. franç. du Caire*, XVII (1937), pp. 118, 119; Pl. XVI. F. Bisson de la Roque, Le Trésor de Tôd, *Chronique d'Égypte* 1937, pp. 21–6.

[6] J. H. Breasted, *op. cit.*, II, 446. [7] II, 485. [8] II, 482.
[9] II, 447, 491, 518, 820. [10] II, 584. [11] II, 459, 490.
[12] III, 116, 274. [13] III, 420. [14] III, 434. [15] III, 584.

knowledge to enable them to separate minute proportions of silver from lead ores (though these were worked for galena to use as an eye-paint and also for smelting to obtain the metal), much less from nickel ores (which were not worked at all anciently), what then was the source of the ancient silver? It could not have been obtained from the local gold and electrum, though these contain considerable proportions, since the necessary knowledge of how to separate silver from gold was lacking, even as late as Greek times, as is proved by the method of refining gold (chiefly from silver) described by Agatharchides,[1] in which the silver was converted into chloride and rejected. In my opinion, there is no doubt that, both in Egypt and in western Asia, there were alloys of gold and silver, of the nature of electrum, so rich in silver that they were silver-white[2] and that it was these alloys that constituted the first ancient silver, that is to say they were 'white gold,' which is what the Egyptians called silver. This seems to be proved by the fact that all the early silver from Egypt is in fact such an alloy and contains gold, sometimes in considerable proportion, the specimens of which analyses are available containing from 1.0 per cent to 38.1 per cent of gold.[3]

None of the Egyptian silver is of the nature or purity of that smelted from ore. Thus, some is not of a uniform white colour, as would be the case had it been obtained from ore, when necessarily it would have been melted and well mixed, but has yellowish patches manifestly due to the unequal distribution of the gold present. This occurs on the anklets of Hetepheres (Fourth Dynasty); on several of the objects from the tomb of Tut-ankhamun (Eighteenth Dynasty); on bracelets and on metal 'gloves' of late Nineteenth Dynasty date.[4]

That the ancient gold and electrum were natural products that still occur in Egypt will generally be admitted, and it is not unreasonable to suppose, therefore, that the silver was also a natural product, though the fact that an alloy of gold and silver, containing so large a proportion of the latter as to have a white colour, is still to be found is not usually recognized. Nowadays, however, such an alloy would generally be classed as a poor quality gold and its true character might be masked by the manner in which it would be considered and reported. Anciently the case was different: silver was scarce and in consequence was several times the value of gold and hence it would have been the object of diligent search and even the smallest deposits found would have been

[1] See p. 263. [2] See p. 267. [3] See p. 546.
[4] Cairo Museum, Nos. C.G. 52577–8 and C.G. 52708–9.

highly prized and would have been worked until exhausted. That it still occurs, however, is proved by the results of the assay (by A. C. Claudet) of twenty-six specimens of modern Egyptian gold from quartz quoted by Alford.[1] When the ratio of silver to gold in these specimens is calculated it is seen that in fifteen instances this is one part or more of silver to one part of gold, the highest ratio being 3.3 parts of silver to one part of gold. All these specimens, therefore, would be silver-white, since a silver-gold alloy containing 50 per cent or more of silver has a white colour. Mellor mentions a specimen of natural silver-gold alloy from Norway that contained 28 per cent of gold and, therefore, by inference, 72 per cent of silver,[2] which also would be white.

Eventually, silver was obtained, as it is largely to-day, from argentiferous lead ores, which is proved, by the exploitation of the mines of Mount Laurion in Attica (Greece), certainly as early as the fifth[3] and fourth centuries[4, 5] B.C. and probably earlier. It is unlikely, however, that these, or indeed any Greek mines, were the first to be worked and probable that the earliest production of silver from an ore (which was certainly argentiferous lead ore) took place in western Asia, where such ores occur extensively. In Anatolia and Armenia there are many ancient silver mines, which unfortunately cannot be dated, the ores being chiefly argentiferous, galena associated with sulphide of zinc.[6] In Georgia and Caucasia there are also similar ores, though whether they were worked anciently or not is uncertain.[7] In Persia, too, lead ores containing silver are widely distributed, but again it is not known whether they were exploited anciently or not.[8, 9]

Pliny states[10] that 'The Egyptians stain silver,' and he goes on to say that 'strange to relate the value of the silver is enhanced when its splendour has been sullied. The preparation is as follows: one-third of a part of the finest Cyprian copper . . . is mixed with one part of silver and the same amount of live sulphur. The whole is heated in an earthen crucible luted with clay . . .' 'Silver can also be tarnished with

[1] C. J. Alford, *A Report on Ancient and Prospective Gold Mining in Egypt*, 1900, Appendix.
[2] J. W. Mellor, *Inorganic and Theoretical Chemistry*, III, p. 299.
[3] Herodotus, VII: 144. [4] Xenophon, *Essay on the Revenue of Athens*, IV.
[5] Aristotle, *Constitution of Athens*, XLVII.
[6] H. A. Karajian, *Mineral Resources of Armenia and Anatolia*, pp. 140–60.
[7] D. Ghambashidze, *Mineral Resources of Georgia and Caucasia*, pp. 44–9.
[8] Moustafa Khan Fateh, *The Economic Position of Persia*, p. 32.
[9] Geog. Section, Naval Intell. Division, Admiralty, London, *Geology of Mesopotamia and its Borderlands*, p. 69.
[10] XXXIII: 46.

the yolk of a hard-boiled egg.' The word 'stain' (*tinguit*) suggests some method of treating a silver object whereby it acquired a dark or black colour, particularly in view of the statement about tarnishing (*nigrescit*) silver by means of the sulphur compounds in egg-yolk, but the description given is not that of making a stain or varnish to be applied to silver, but of producing an alloy of silver and copper blackened by the sulphides of these metals, and apparently it was this black alloy that was employed in place of pure white silver, a strange taste, as Pliny remarks. This description strongly suggests niello, a few examples of which are known from ancient Egypt. One of these is on the dagger of King Amosis from the beginning of the Eighteenth Dynasty, now in the Cairo Museum. The blade of the dagger is gold with a narrow band of black material down the centre of each side, this band being inlaid with inscriptions and designs in gold wire. Manifestly the black material has been introduced into position while in a plastic condition and while still in that state the gold ornamentation must have been inserted. The composition of the black material has not been determined, but it is certainly not a metal, though it may well be silver sulphide, or a mixture of metallic sulphides, and, if so, it is niello, which Vernier calls it,[1] and which he defines as a metallic sulphide employed by jewellers in the manner of black enamel. Another Egyptian example of what is thought to be niello is on a small bronze case of Twenty-fifth Dynasty date in the Louvre Museum. This case was examined carefully and the material analysed by Berthelot.[2] It consists of bronze containing a large proportion of lead and is coated on both sides with a layer of black material about 0.5 mm. thick, which Berthelot considered to be niello. This, like the material of the case, contains copper (a large proportion) and tin, but sulphide is also present and a trace of fatty matter. Inlaid in the black material are inscriptions and designs, which can have been put in position only while the black material was plastic.

Silver Plating

The Egyptians early knew how to plate copper with silver, as is proved by a copper ewer of the Second Dynasty found by Brunton.[3] Professor Thompson, reporting upon this, says, 'The

[1] E. Vernier, La bijouterie et la joaillerie Égyptiennes, *Mém. de l'Inst. franç. d'arch. orientale du Caire*, II (1907), pp. 28–31; Pl. XXIV (2).
[2] M. Berthelot, *Mon. et Mém. Piot*, VII (1900), pp. 121–41; Pls. XII, XIII.
[3] G. Brunton, *Qau and Badari*, I, p. 69; Pl. XVIII (10).

material of which the ewer is made contains tin. Whether this is present in sufficient quantity to constitute a bronze[1] cannot be determined without destroying the sample. The material is cold-worked and appears to have been hammered to shape from a sheet. There is a definite coating of either silver or tin on the outside of the ewer. The former is the more probable, though one cannot be sure without spoiling the vase. There are indications that this plating was done by hammering the other metal on the copper or bronze before the ewer was made. The spout appears to have been hammered on to the rest of the body.' This ewer was further examined by Professor H. B. Dixon, who stated that silver was certainly present on the surface of the copper as a very thin layer and tin absent, the silver having been put on either in the pure state or alloyed with copper. Neither the finder nor Professor Thompson nor Professor Dixon gives any details of the extent of the silver 'plating.' If it occurred only round where the spout was fastened in may it not have been silver solder, such as that already mentioned,[2] which had spread beyond the join? As an explanation of the method of plating employed, Brunton adopted a suggestion put forward by me, that the technique might have been analogous to that employed for making the 'gold' thread required in the manufacture of the 'Holy Carpet' formerly sent annually by the Egyptian Government to Mecca. This so-called 'gold' thread, which was really silver thread covered with a thin coating of gold, was made as follows[3]: A thick bar of silver was wrapped round with thin sheets of gold and heated in a small charcoal furnace, from which it was periodically removed and well rubbed with a thick agate rod, the gold eventually alloying with the silver, forming a thin, uniform, strongly and closely adherent coating. This was then passed through a series of draw-plates until thread of the required thinness was obtained, which had all the appearance of being gold though it was only silver plated with gold. Two small rectangular objects of copper (possibly knives or razors) of Old Kingdom date from Edfu have also been silvered.[4]

The principal use of silver anciently was for beads, jewellery, bowls and vases, though, like gold, it was also beaten into foil and thin leaf

[1] Bronze may almost certainly be excluded at so early a date as the Second Dynasty.

[2] See p. 248.

[3] A. Lucas and B. F. E. Keeling, *The Manufacture of the Holy Carpet*, in *Cairo Scientific Journal*, VII (1913), pp. 129–30.

[4] Cairo Museum, Nos. 71827 A and B.

and used for covering wood, examples of foil occurring for the garments of the king and queen on the throne of Tut-ankhamun; for the ' slippers ' on the bottom of the legs of a box; covering the sledge of a small shrine; covering the staples on the large shrines and the handles of the two sledges carrying the canopic box; and examples of leaf being on a writing board from this same tomb; on a head-rest from the tomb of Hetepheres (Fourth Dynasty); and on one of the coffins and a bed from the tomb of Yuya and Thuyu (Eighteenth Dynasty). One instance of the use of silver at an early date for soldering copper has already been given[1] as also an instance of its use for plating copper.

Pure silver melts at 960.5° C. (1,760.9° F.), this melting point being raised by the presence of gold or copper.[2]

Tin

The word ' tin ' is often used loosely to designate both the metal and the ore, but in order to avoid ambiguity and misunderstanding, the term will here be restricted to its correct meaning of the metal.

In antiquity the principal use of tin was for making bronze, though occasionally it was employed alone. The early history of tin is very obscure and no evidence can be found to show when it was first discovered. The sequence of tin and bronze is also uncertain, though from the fact that the first recorded appearance of tin was in the form of its alloy bronze, as also from theoretical considerations, the probability is that bronze was made some considerable time before tin as an individual metal was isolated, just as brass (an alloy of copper and zinc) was known long before zinc itself was discovered. Either tin or tin ore, however, must have been used to produce bronze, of which tin is an indispensable constituent, though if the ore, as distinguished from the metal, were employed, it need not necessarily have been recognized at first as being essentially different from copper, all the knowledge required being a realization that ore from a certain place when added to copper ore produced an improved form of copper.

Until recently it was thought that tin ore did not occur in Egypt, but a thin vein of tin oxide (cassiterite) was found in 1935 near Gebel Muelih, in the eastern desert, roughly half-way between Edfu and the

[1] See p. 248.

[2] General reference: G. A. Wainwright, A Hoard of Silver from Menshah, Girga Mudiriah, *Annales du Service*, XXV (1925), pp. 120–9.

Red Sea, and in 1940 further deposits were found in Gebel el Agala district in the neighbourhood of Quseir on the Red Sea coast, and in 1941 a small works was erected by the Egyptian Government, the ore being smelted on the spot. There is no evidence that this occurrence was known or worked anciently. The earliest use of tin, apart from bronze, and the earliest references to tin known to me are Egyptian. Thus the first objects of tin of which any records can be traced, namely a ring[1, 2] (or rather the bezel of a ring, now in the museum of University College, London) and a pilgrim bottle,[3] are from Egyptian graves of the Eighteenth Dynasty (1580 B.C. to 1350 B.C.). A ring, consisting of an alloy of tin and silver, is also known from the same period,[4] and an ore of tin (the oxide) was employed in Egypt in small amount from the Eighteenth Dynasty onwards for imparting a white opaque colour to glass,[5, 6] and such an oxide was found in the tomb of Tut-ankhamun.[7] After this in chronological order comes an object of tin having the outlines of a winged scarab, which probably dates from about 600–700 B.C.[8]: from the Roman period in Nubia there are two finger rings of tin,[9] two bronze bowls that have been tinned[9] and a bowl of pewter,[9] an alloy of lead and tin; in the third century A.D. tin plates inscribed with magical charms are mentioned[10]; and in A.D. 572 there is a recipe for making solder from lead (80 per cent) and tin (20 per cent) for soldering the pipes of a bath.[11]

The earliest references to tin that can be found are three that occur in the Harris Papyrus,[12] an Egyptian document of the Twentieth Dynasty (1200 B.C. to 1090 B.C.). The next references in chronological order are in Homer[13] (ninth century B.C.), then another Egyptian reference of the Twenty-fifth Dynasty[12] (712 B.C. to 663 B.C.), after

[1] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 104.
[2] J. H. Gladstone, *On Metallic Copper, Tin and Antimony from Ancient Egypt*, in *Proc. Soc. Bibl. Arch.*, XIV (1892), p. 226.
[3] E. R. Ayrton, C. T. Curelly and A. E. P. Weigall, *Abydos*, III, p. 50.
[4] C. R. Williams, *Gold and Silver Jewelry and Related Objects*, pp. 29, 92.
[5] B. Neumann and G. Kotyga, *Z. für angew. Chem.*, 1925, pp. 776–80, 857–64.
[6] H. D. Parodi, *La verrerie en Égypte*, pp. 34, 45.
[7] A. Lucas, *Appendix II*, in *The Tomb of Tut-ankh-Amen*, Howard Carter, III, pp. 176–7.
[8] A. H. Church, *Chemical News*, 1877, p. 168.
[9] C. L. Woolley and D. R. Randall-MacIver, *Karanog*, III, p. 67.
[10] F. G. Kenyon, *Greek Papyri in the British Museum*, I, pp. 91, 93, 97, 99.
[11] B. P. Grenfell and A. S. Hunt, *The Oxyrhynchus Papyri*, VI, pp. 268–9.
[12] J. H. Breasted, *Ancient Records of Egypt*, IV, 245, 302, 385, 929. The meaning of the word translated 'tin' is, however, stated to be doubtful.
[13] *Iliad*, XI: 25, 34; XVIII: 474, 565; XX: 271; XXI: 592; XXIII: 503, 561.

which come four references in the Bible,[1] one in Numbers (about fifth century B.C.), a doubtful one in Isaiah (either eighth or fifth century B.C.) and two in Ezekiel (sixth century B.C.), then Herodotus[2] (fifth century B.C.), Diodorus Siculus[3] (first century B.C.), Julius Caesar[4] (first century B.C.), Strabo[5] (first century B.C. to first century A.D., in one instance quoting Posidonius of the second to first century B.C.), Pliny[6] (first century A.D.) and other classical writers.

In the first century A.D. tin was being shipped by way of Egypt to Somaliland and India,[7] but from where it was obtained is not stated.

Tin does not occur naturally in the metallic condition, the form in which it is found in nature being in the combined state as a mineral, the principal and only tin mineral of importance being the oxide (cassiterite or tinstone), though a sulphide combined with the sulphides of copper and iron (stannite, stannine or tin pyrites) is also found in small quantity in certain localities.

Metallic tin, which melts at 232° C., is one of the easiest metals to produce and it may be obtained by simply heating the oxide with charcoal, this being the fuel employed anciently and the fuel generally used for smelting until about the eighteenth century A.D. The metal, however, cannot be produced from the sulphide by any such simple means, which is proof that this ore was not employed anciently as a source of tin.

Tin oxide occurs in two forms, one in veins (lodes), frequently in granite or granitic rocks and occasionally associated with copper ore, and the other as pebbles, gravel or sand, derived from the disintegration of rocks bearing vein ore, the debris from which has been carried and deposited by water.

Tin ore (cassiterite) is heavy and usually dark brown or black in colour and, except the weight, there is nothing to suggest that it is a metallic compound. It is frequently found in the same alluvial gravels as gold, and since both are obtained by the same method, namely by washing away the lighter material with running water, it is exceedingly probable that when gold was being searched for the heavy tin oxide, which, however, is not nearly so heavy as gold, would be noticed,

[1] *Numbers*, 31: 22; *Isaiah*, 1: 25 (the R.V. gives the alternative reading 'alloy'); *Ezekiel*, 22: 18, 20; 27: 12.
[2] III: 115.
[3] V: 2.
[4] *De Bello Gallico*, V: 12.
[5] III: 2, 9; 5, 11; XV: 2, 10.
[6] IV: 30, 34, 36; VII: 57; XXXIV: 47, 48.
[7] W. H. Schoff, *The Periplus of the Erythraean Sea*, pp. 33, 42, 45.

and it seems likely that the alluvial ore was discovered in this manner. On account of this association with gold, and also because the alluvial ore occurs in more accessible places and is more easily mined than the vein ore, it was probably alluvial ore that was worked first deliberately as a separate ore.

Claims have been made for Europe, Africa and Asia respectively as the place where tin was first discovered and the home therefore probably of bronze.

The claim for the European origin of tin[1] and bronze[2] has not found general support and, in my opinion, there is neither evidence nor probability that tin was being mined and bronze made in Central Europe as early as the Fourth Dynasty (about 2900 B.C. to 2750 B.C.), the possible date of two Egyptian bronze objects,[3] nor even at the time of the Middle Kingdom (about 2000 B.C.), from which period a number of bronze objects have been found in Egypt.[4] That the still earlier Asiatic bronze should have come from Europe is even more unlikely.

With respect to Africa, although tin ores occur plentifully,[5] it is inconceivable that important materials, such as tin (or tin ore) and bronze, should have been traded in quantity for centuries to Egypt, and possibly through Egypt to Asia and Europe, without leaving some evidence of the traffic or some traces or knowledge of either tin or bronze on the way, and no such evidence or traces are known. Also, this would not explain the possession of bronze in Mesopotamia at a date considerably earlier than it was known in Egypt, unless the Mesopotamian bronze did not pass through Egypt, but reached that country by sea, and that any trade, much less a regular trade, should have been carried on between East Africa and the Persian Gulf as early as about 3500 B.C. to 3200 B.C., which is the approximate date of the earliest bronze found in Mesopotamia,[6] is most improbable.

From the evidence at present available there seems no doubt that the home of both tin and bronze was in western Asia and it has been thought that the special locality was possibly in north-east Persia, where both tin and copper ores are known to occur.[7] Wainwright, however.

[1] W. M. F. Petrie, *Medum*, p. 44.

[2] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, 1910, p. 101; H. C. Richardson, *American Journal of Archaeology*, XXXVIII (1934), p. 555.

[3] See p. 252. [4] See p. 253.

[5] A. Lucas, *Notes on the Early History of Tin and Bronze*, in *Journal of Egyptian Archaeology*, XIV (1928), pp. 100–1. [6] See p. 250.

[7] A. Lucas, *op. cit.*, pp. 100, 108. See also O. G. S. Crawford, *Antiquity*, XII (1938), pp. 79–81: H. Field and E. Prostov, *Antiquity*, XII (1938), pp. 341–5.

has published an important article in which he shows that a likely early source of tin and bronze, particularly of the Egyptian supply, was the Kesrwan district of Syria,[1] which is situated a little to the north-east of the modern town of Beyrut, to the occurrence of tin in which I drew attention several years ago,[2] without, however, realizing its importance. Wainwright shows that both tin ore and copper ore occur in the mountains of the Kesrwan district, through which flow two rivers, the Nahr Ibrahim and the Nahr Feidar (the ancient Adonis and Phaedrus) which enter the sea near the site of the ancient town of Byblos, which was *the* port for Egyptian trade from at least as early as the First Dynasty.

No evidence is known of either ancient or modern mining in the Kesrwan Mountains, but the country was prospected some years ago by two Australian mining engineers, who applied for the right to mine tin, copper and silver ores, which, therefore, they must have been satisfied existed in quantity, the work, however, being suspended on the outbreak of war and never resumed.[3] Wainwright suggests that fragments of tin ore or copper ore, or both, may have been brought down by the two rivers mentioned, the Adonis having a strong current all the year round and the Phaedrus a ' considerable flood after heavy rains,' though it dries up during the summer. This dried river bed would have been a most likely place for discovering and collecting any fragments of ore there may have been, and it should not be forgotten that in the West, where alone there is early written evidence of tin working, the ore, which was alluvial, was derived from the dried beds of ancient water-courses. Thus, referring to Spain-Portugal, Strabo (first century B.C. to first century A.D.) quotes Posidonius[4] (second to first century B.C.) for the statement that the earth in which the tin ore occurred was ' brought down by the rivers: this the women scrape up with spades and wash in sieves . . .' and Pliny (first century A.D.) says[5] of the same Spanish-Portuguese tin ore that ' It is a sand found on the surface of the earth, and of a black colour, and it is only to be detected by its weight. It is mingled with small pebbles, particularly in the dried beds of rivers.' Manifestly, therefore, the ore described by both these writers was alluvial.

[1] G. A. Wainwright, in *Journal of Egyptian Archaeology*, XX (1934), pp. 29–32. See also G. A. Wainwright, Early Tin in the Aegean, *Antiquity*, 18 (1944), pp. 57–64.

[2] A. Lucas, *op. cit.*, XIV (1928), p. 100.

[3] I. M. Toll, *The Mineral Resources of Syria*, in *Eng. and Mining Journal*, CXII (1921), p. 851.

[4] III: 2, 9.

[5] XXXIV: 47.

Diodorus, writing with reference to the inhabitants of Cornwall, states[1] that 'These are the people that make the tin, which with a great deal of care and labour they dig out of the ground; and that being rocky, the metal is mixed with some veins of earth, out of which they melt the metal and then refine it.' Although at first sight this description might suggest the mining of vein and not alluvial ore, it was almost certainly the latter that was meant, since in certain districts in Cornwall the alluvial gravels are not on the surface, but in one place, for example, they are beneath some 50 feet of sand and silt and in another place they are covered with peat, gravel and sand to a depth of 20 feet.[2] Also, all the available evidence points to 'tin streaming,' as it was termed, having been a much older industry in Cornwall than the mining of vein ore.

In view of the probability, as shown by Wainwright, that some at least of the early tin ore found in the East was alluvial and was possibly accompanied by copper ore (almost certainly malachite, the usual ore of surface copper deposits, which would have been well known at the time and recognized as yielding copper when smelted), the explanation previously given by me to account for the discovery of tin and bronze[3] may be much simplified. Although it was recognized that 'it was probably alluvial ore that was worked first deliberately as a separate ore,'[3] it was assumed that bronze was first made accidentally by smelting associated ores of copper and tin, both derived from veins,[4] because no association of copper ore and alluvial tin ore was known, but it is now suggested that the sequence of events may have been much as follows: First, the discovery of alluvial tin ore, possibly on the banks or in the bed of either the Adonis or Phaedrus, or both, and probably during a search for gold.[5]

Second, the realization that the comparatively heavy tin ore might be metalliferous, possibly even a kind of copper ore, and the consequent smelting of it, either alone, when tin would have been discovered, or more probably mixed with copper ore, when bronze would have been made.

Third, when the alluvial tin ore first found, which probably only occurred in comparatively small amount, was becoming exhausted, search was made for other supplies and the sources in Spain-Portugal, Cornwall, Brittany and elsewhere manifestly became known and

[1] v: 2.
[2] G. M. Davies, *Tin Ores*, pp. 28, 29.
[3] A. Lucas, *op. cit.*, p. 98.
[4] A. Lucas, *op. cit.*, p. 107.
[5] See pp. 287–9.

eventually, at a very much later date and in some places only, the parent veins (lodes) from which some of the alluvial ore had originally been derived were tracked down and worked.

It should be pointed out that the hypothesis of the possible discovery of tin ore and bronze in a district in such close touch with Egypt, as was the neighbourhood of Byblos, leaves unexplained the fact of the knowledge of bronze in Mesopotamia at a much earlier date than in Egypt, unless other and earlier sources of tin ore were also known.

Hintze is quoted by von Bissing[1] for the statement 'that at Eskishehir[2] in Central Asia Minor, tin has been found quite recently, and that the mines were exploited under the old Turkish government.'

MINERALS

The dictionary definition of a mineral is 'a substance obtained by mining,' but the word is here used, not in this wide sense, but with a very restricted meaning, since the most important minerals, namely, the metals and their ores, have already been dealt with, and certain other mineral substances, such as building stone, gypsum, ochres, orpiment, precious, semi-precious and other stones, either have been, or will be, separately described. The minerals to be discussed are alum, cobalt compounds, emery, graphite, manganese compounds, mica, natron, nitre, salt and sulphur.

ALUM

So far as can be ascertained, alum has never been discovered in connexion with ancient Egypt, and the evidence for its use is entirely circumstantial, namely, that alum occurs in Egypt; that it was mined anciently and that it was almost certainly the mordant to which Pliny refers that was employed in Egypt for fixing the colours during the dyeing of cloth.[3] These statements will now be proved.

Alum occurs in the Oases of Dakhla and Kharga, which are situated in the desert west of the Nile valley; in Dakhla it is 'widely distributed in small quantities'[4]; in Kharga there are 'ancient mines of the most extensive description'[5]; 'hills . . . literally honeycombed with ancient workings'[5]; 'Huge dump heaps'[5] and 'The extent and magnitude

[1] F. W. von Bissing, *Journal of Hellenic Studies*, LII (1932), p. 119.
[2] Called Eski Shehr by Wainwright (*op. cit.*, p. 29).
[3] XXXV: 42.
[4] H. J. L. Beadnell, *Dakhla Oasis, Its Topog. and Geology*, pp. 100–1.
[5] H. J. L. Beadnell, *An Egyptian Oasis*, pp. 220–3.

of the underground workings prove that whatever the mineral mined, it was a substance of considerable value in those days; and an examination of the blind termination of the tunnels occasionally reveals the presence of very thin seams of aluminium sulphate, which . . . we must conclude was the substance sought.'[1] Miss Caton-Thompson and Miss Gardner state that 'miles of outlying foothills and desert floor alike were seen to be riddled with shallow workings, giving the ground the appearance of having been shelled.'[2] 'Alum seems most likely to be the mineral sought.'[2] The deposits in Kharga were worked during 1918–19, when about 222 metric tons of alum were extracted.[3]

Some part at least of this mining is undoubtedly comparatively modern, thus Maqrizi states[4] that in Arab times 1,000 *kantars* (44 tons) of alum were sent annually from the Oases to Cairo; another Arab writer says[5] that the receipts from the alum mines formed part of the Government revenue; and in 1809 Hamilton wrote[6]: 'The trade of Goubanieh, which is a few miles below As Souan, consists in the fitting out annually a caravan of fifty camels for the purpose of procuring alum from a low spot in the Desert, ten or eleven days' journey South-West of the Cataracts. It is found in a single stratum from two to fifteen inches in depth covered with a layer of dry sand about half a foot thick and resting on a bed of moist sand. The alum when taken is broken in pieces, dried in the sun and at Goubanieh is sold at seven *pataques* the *ardeb*.'[7]

But this was not the earliest mining, as Herodotus (fifth century B.C.) says[8] that King Amasis (569 to 526 B.C.) sent from Egypt a thousand *talents'* worth of astringent earth (almost certainly alum) as a contribution towards the rebuilding of the temple at Delphi and that the Greek dwellers in Egypt sent a further twenty *minae* worth. Egyptian alum was also known to the Romans of Pliny's day (first century A.D.)

[1] H. J. L. Beadnell, *An Egyptian Oasis*, pp. 220–3.

[2] G. Caton-Thompson and E. W. Gardner, *The Prehistoric Geography of Kharga Oasis*, in *The Geographical Journal*, LXXX (1932), p. 372.

[3] For a chemical analysis see G. Hogan, Note on the Deposits of Aluminium Sulphate at Kharga Oasis, Egyptian Water Supplies, *Report and Notes of the Public Health Laboratories*, Cairo, 1920, pp. 11–2.

[4] Maqrizi, *Description topographique et historique de l'Égypte*, in *Mém. de la mission arch. franc. au Caire*, 1900, pp. 17, 691, 697, 698.

[5] Stanley Lane-Poole, *A History of Egypt in the Middle Ages*, p. 304.

[6] W. Hamilton, *Remarks on Several Parts of Turkey, Part I, Aegyptiaca*, p. 428.

[7] This account apparently is taken from Girard (P. S. Girard, Mém. sur l'agriculture, l'industrie et le commerce de l'Égypte, *Description d'Égypte, état moderne*, II, p. 623).

[8] II: 180.

since this writer, when enumerating the different sources of alum, includes Egypt and states that the Egyptian alum was 'the most esteemed.'[1] Miss Caton-Thompson and Miss Gardner state[2] that 'Sherds collected in field examination of mining areas . . . confirmed their Roman date.' Dioscorides states[3] that 'Almost every kind of alum is found in the same mines in Egypt.' Egyptian alum is also mentioned in one papyrus found in Egypt,[4] but unfortunately undated, and in two others dated A.D. 229 and A.D. 300 respectively.[5]

At the present time, alum is employed, both as a mordant in dyeing and as a medicine, and Pliny refers to its use for both these purposes[1] and, therefore, when he also mentions the use in Egypt for dyeing cloth of what is certainly a mordant,[6] it is not unreasonable to suppose that he was referring to alum, more especially as alum occurs in Egypt, where it had been mined for several centuries at least before Pliny wrote.

Cobalt Compounds

The chief value of cobalt compounds is the deep permanent blue colour of some of them, on account of which they are highly esteemed as pigments by artists and are also employed to impart a blue colour to glass. So far as is known, cobalt blue was not employed as a pigment in ancient Egypt, although two instances of its alleged use have been reported. One of these is the statement by Toch[7] that he had found cobalt blue pigment on the walls of the Fifth Dynasty tomb of Per-neb. This has since been shown to be a mistake, all the blue pigment in the tomb being the well-known blue frit coloured by means of a copper compound.[8] The other instance of the supposed use of cobalt blue is the statement by Wiedemann that Hofmann had found a blue pigment of the time of Ramesses III (Twentieth Dynasty) to be a cobalt colour.[9] This, however, Mrs. Williams finds to be an error, Hofmann's

[1] xxxv: 52.
[2] G. Caton-Thompson and E. W. Gardner, *op. cit.*, p. 372.
[3] v: 123.
[4] B. P. Grenfell and A. S. Hunt, *The Oxyrhynchus Papyri*, II (1899), pp. 134–6.
[5] A. S. Hunt, *The Oxyrhynchus Papyri*, XVII, No. 2116: B. P. Grenfell and A. S. Hunt, *op. cit.*, XII, No. 1429.
[6] xxxv: 42.
[7] M. Toch, *The Pigments from the Tomb of Perneb*, in *Journ. Ind. and Eng. Chemistry*, 1918, p. 118.
[8] C. R. Williams, *The Decoration of the Tomb of Per-neb*, p. 27, *n.* 34.
[9] A. Wiedemann, *Cobalt in Ancient Egypt*, in *Proc. Soc. Bibl. Arch.*, XV (1892–93), pp. 113–4.

reference being not to the use of cobalt blue as a pigment, but to the employment of smalt,[1] an artificial preparation of the nature of glass coloured by a cobalt compound, which, although it might be used as a pigment, might equally well have been for colouring glass.

The occasional use of cobalt compound for colouring blue glass has been dealt with in connexion with glass, the earliest date from which it is reported being the Eighteenth Dynasty.[2]

Cobalt ores, so far as is known, do not occur in Egypt, the only cobalt compounds yet found being traces in the alum minerals of both Kharga and Dakhla Oases[3, 4] and in the nickel ore of St. John's Island in the Red Sea,[5] these occurrences being certainly unknown anciently and the compounds presenting almost insuperable difficulties of extraction. Any cobalt compound used, therefore, must have been imported, possibly from Persia or the Caucasus region, in both of which places cobalt ores occur. Traces of cobalt compounds have also occasionally been found in ancient Egyptian copper and bronze objects and in a specimen of ancient slag from Sinai,[6] which suggests that they may be present as traces in the Egyptian copper ore.

Emery

Emery is a greyish-black variety of corundum and consists essentially of oxide of aluminium, though it also contains an admixture of oxide of iron; its hardness is next to that of the diamond and when finely powdered it is largely used as an abrasive.

Beyond a statement that some of the sand at Aswan contains 15 per cent of emery,[7] which has never been confirmed, there is no evidence of its occurrence in Egypt, but it is found plentifully in Asia Minor and in several of the Aegean islands.

A few objects, stated to be of emery (probably because the material scratches glass), mostly dating from predynastic and early dynastic times have been found in Egypt: these include a plummet,[8, 9] a vase,[10] a tool,[11] three small blocks[8, 9] (thought to have been used for polishing

[1] C. R. Williams, *op. cit.*, p. 27, *n.* 29. [2] See p. 217.
[3] H. J. L. Beadnell, *An Egyptian Oasis*, p. 222.
[4] W. F. Hume, *Explan. Notes to the Geol. Map of Egypt*, p. 40.
[5] F. W. Moon, *op. cit.*, p. 16.
[6] J. Sebelien, *Early Copper and its Alloys*, in *Ancient Egypt*, 1924, p. 10.
[7] G. A. Wainwright, *Balabish*, p. 38.
[8] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 29, 44, 45, 48.
[9] W. M. F. Petrie, *Prehistoric Egypt*, pp. 41–2.
[10] J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 50.
[11] J. E. Quibell, *Archaic Objects*, p. 304.

beads because of their grooved condition), a piece[1] and several hones,[2] the date of the latter being unknown. The plummet, which was examined at the British Museum laboratory, was reported by Dr. Plenderleith to be ferruginous sandstone and not emery.[3] The tool[4] was kindly examined for me by Mr. O. H. Little, Director of the Geological Survey, Egypt, and it also was found to be ferruginous sandstone and not emery. The specific gravity is only 1.47. Two of the blocks[5] I was allowed to examine by Professor Glanville and the third[6] (which is at the Ashmolean Museum, Oxford) by Mr. Leeds. All three are ferruginous sandstone and not emery. Another object[7] called ' fragment of a corundum vase ' is also ferruginous sandstone and probably is not part of a vase. In my opinion the blocks have not been used for grinding either beads or other objects, but may be moulds for tubular beads. It is often stated that emery was employed in ancient Egypt as an abrasive with drills and saws for working hard stones and, although some abrasive powder must have been used, it has never been proved that the material was emery, which in my opinion is most improbable. This alleged use of emery as an abrasive has already been dealt with fully in connexion with stone working.[8]

GRAPHITE

Graphite (often termed plumbago or blacklead) is a soft, black or dark grey substance consisting largely of carbon, the proportion of which usually varies from about 50 to 97 per cent, the admixture being clay and other impurities. It is widely distributed in nature and occurs in Egypt in certain schists in the eastern desert, especially in the gold-mining areas[9] and in the beryl-mica-schists at Wadi Um Deba'a[10] and in the quartz veins of the gold-bearing rocks.

A few specimens of graphite have been found in connexion with ancient Egypt, one of Sixth Dynasty date from Gebelein[11]; one

[1] D. Randall-MacIver and A. C. Mace, *El Amrah and Abydos*, p. 49.
[2] British Museum, *A Guide to the Third and Fourth Egyptian Rooms*, 1904.
[3] University College, London, Museum No. 4431 A. The analytical report was kindly shown to me by Professor S. R. K. Glanville.
[4] Cairo Museum, No. C.G. 14679.
[5] University College Museum, Nos. 4796 A and 5662.
[6] Nos. 1895–992, Ashmolean Museum. *Summary Guide*, 1931, p. 40.
[7] Nos. 1895–991, Ashmolean Museum. *Summary Guide*, 1931, p. 40.
[8] See pp. 91–2.
[9] W. F. Hume, *A Prelim. Report on the Geol. of the Eastern Desert*, p. 40.
[10] W. F. Hume, *Geology of Egypt*, II (Part I), pp. 112, 114, 162, 165.
[11] Cairo Museum, No. J. 66842.

of Eighteenth Dynasty date found by Petrie in a house at Gurob[1]; a graphite bead, a small lump and a little powder in one shell, and two other shells, each containing a little powder, found by Steindorff at Aniba in Nubia[2] and a number of small pieces found by Reisner at Kerma in the Sudan,[3] where it was used for blackening certain pottery. The Gurob specimen was analysed by Dr. Ainsworth Mitchell and proved to be very impure, containing much siliceous matter and only 39 per cent of carbon.[4]

Manganese Compounds

Manganese occurs in nature chiefly combined with oxygen as oxides, which are widely distributed in Egypt, the Nubian sandstone, for example, being permeated with veins of these compounds: they also occur at Gebel Ruzza north of the Fayum, at Gebel Alda in the northern part of the Red Sea hills, and plentifully in Sinai, where from one area alone 1,084,699 metric tons were extracted during the years 1917 to 1928 inclusive.[5]

Petrie mentions three oxides of manganese, namely, wad (Twelfth Dynasty), pyrolusite (Eighteenth Dynasty), and psilomelane (undated) as having been found on ancient sites, but not known to have been used.[6]

Oxides of manganese were employed in ancient Egypt to impart a purple colour to glaze and glass, but their general use for any other purpose is unknown, though one instance of the use of pyrolusite as a black pigment for tomb-painting (Twelfth Dynasty)[7] is known and also two examples of a black oxide of manganese having been employed for decorating pottery (Eighteenth Dynasty).[8] Oxide of manganese was also used occasionally as an eye-paint.[9] The earliest date recorded for the use of manganese compounds for colouring glass is the Eighteenth Dynasty,[10] but their use for colouring glaze was much earlier, though the precise date is uncertain. These oxides were required

[1] W. M. F. Petrie, *Kahun, Gurob and Hawara*, p. 38.

[2] Examined by me. G. Steindorff, *Aniba*, I, p. 51. Cairo Museum, Nos. J. 65221 *a, b, c, d*.

[3] G. A. Reisner, *Excavations at Kerma*, IV–V, p. 290.

[4] C. A. Mitchell, *Graphites and other Pencil Pigments*, in *The Analyst*, XLVII (1922), p. 380.

[5] Mines and Quarries Department, *Report for 1928*, p. 12.

[6] W. M. F. Petrie, *Descriptive Sociology, Ancient Egyptians*, p. 49.

[7] See p. 392. [8] See p. 441. [9] See p. 100. [10] See p. 215.

anciently in such small quantity and they occur so plentifully in the country, that it is highly improbable there was any importation from abroad. Ancient workings have been reported from one locality in the eastern desert.

Mica

The micas are a group of minerals specially distinguished by their ready cleavage into thin plates: chemically they consist of silicates of aluminium combined with compounds of iron, magnesium, potassium or sodium; they occur as essential constituents of many rocks, such as granite and gneiss, and are very plentiful in Egypt. Mica, in the form of small glittering scales, is often present in Nile silt and in many Egyptian clays, from which sources it finds its way into some of the local pottery and may frequently be seen in both ancient and modern ware.

Mica was used occasionally in Egypt in predynastic times,[1, 2] though for what purpose is unknown; mica mirrors of archaic date have been found in Nubia[3] and in the Egyptian colony of Middle Kingdom date at Kerma in the Sudan small pieces of mica were employed for decorating caps.[4] Mica was also found at Coptos, but no particulars are given.[5]

Natron

Natron is a naturally occurring compound of sodium carbonate and sodium bicarbonate. At the present time it is found in three localities in Egypt, two (the Wadi Natrun and the Beheira province) in Lower Egypt and one (El Kab) in Upper Egypt.

The Wadi Natrun is a depression in the Libyan desert, some 40 miles to the north-west of Cairo; it is about 21 miles long, and at the bottom there is a string of lakes, the water surface of which is about 76 feet (23 metres) below sea level and the number of which fluctuates with the season. During, and for several months after, the Nile flood (which usually begins at Cairo about the end of June and generally reaches its maximum in September, often in the latter half), when there is

[1] W. M. F. Petrie, *Prehistoric Egypt*, p. 44.
[2] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 45.
[3] C. M. Firth, *Arch. Survey of Nubia, Report for 1910–1911*, pp. 201, 209, 210.
[4] G. A. Reisner, *Excavations at Kerma*, IV–V, pp. 272–80.
[5] W. M. F. Petrie, *Koptos*, p. 26.

a considerable increase in the water supply entering the Wadi, and when, on account of the lower temperature during the latter part of the period evaporation has decreased, there were a few years ago, when I stayed in the Wadi on several occasions, 12 lakes.[1] In summer there are always fewer than in winter, as some of the smaller and shallower ones dry up during the hot weather. Lakes varying in number from 7 to 16 are mentioned by different writers about the end of last century,[2] though at the beginning of the century there were apparently only 6.[3] At a still earlier date, however, there would seem to have been only either one or two lakes. Thus in 1780 Sonnini mentions two,[4] which he says became merged into one during the winter; in 1849 Gmelin describes one ' pit,' [5] as he terms it, but at what time of the year is not stated.

The natron in the Wadi Natrun occurs dissolved in the lake water—from which a thick layer has gradually been deposited at the bottom of some of the lakes—and also as an incrustation on the ground adjoining many of the lakes. The amount present is very considerable, although the Wadi has been the source, not only of the principal Egyptian supply, but also of a small export trade, for several thousands of years.

About 30 miles due north of the Wadi Natrun, in the Beheira province, and some 14 miles to the west of the ruins of the ancient city of Naucratis, there is another, but much smaller, depression, slightly below sea level, in which also are a number of shallow lakes containing natron, the largest having an area of between 200 and 300 acres. In September each year the level of the subsoil water, owing to the general rise of the subsoil water of the Delta and the infiltration from neighbouring canals that run full during the Nile flood, begins to rise and manifests itself in such a manner that by December the permanent lakes have increased in size and other temporary shallower ones have been formed. During the summer the area partly dries up, leaving the natron in an easily accessible form. The amount of available material, though large, is very much less than that in the

[1] One of these lakes was largely, if not wholly, caused by the waste water from the factory.

[2] A. Lucas, *Natural Soda Deposits in Egypt* (1912), p. 2.

[3] General Andréossy, *Mémoire sur la vallée des lacs de natroun*, in *Description de l'Égypte*, I (Paris, 1809), État moderne, p. 281.

[4] C. S. Sonnini, *Travels in Upper and Lower Egypt* (1780), trans. H. Hunter, II (1807), p. 139.

[5] L. Gmelin, *Handbook of Chemistry*, trans. H. Watts, III (1849), p. 78.

Wadi Natrun.[1] These deposits were known to Sonnini in 1780, who rightly places them near Damanhur[2]; at one time they were considered worked out, but during the past twelve years they have been exploited again to a small extent. This district is generally called either Barnugi or Harrara after two of the lakes, which are named from neighbouring villages. Browne describes the deposits as at Terane.[3]

The El Kab natron deposits have been described by Schweinfurth[4] and very briefly also by Schweinfurth and Lewin[5] and by Somers Clarke.[6] Schweinfurth, who gives a map of the neighbourhood of El Kab, shows five different localities where natron occurs, which he distinguishes as (*a*) the northern natron valley, (*b*) the northern natron plain, (*c*) the southern natron valley, (*d*) a natron efflorescence, and (*e*) the southern natron-salt plain. The natron is readily accessible, as the distance of the deposits from the river is only from about two kilometres to about seven kilometres.

El Kalkashandi, an Arab writer who died at the beginning of the fifteenth century A.D., describes two other natron deposits,[7] one of about 100 acres in extent at Tarabiya, near Behnesah, in Upper Egypt, which he states had been worked since the time of Ibn Tulun (A.D. 835–84) and which yielded an annual revenue of more than £50,000, and the other in the Fakus district in the Eastern Delta. These places are not now known as sources of natron.

In 1799 natron was imported in small quantity from Bir Natrun in the Sudan 125 miles west-south-west of Dongola. It was 'sold at a high price and . . . used principally in making snuff.'[8] Burckhardt, writing in 1819, says that 'Among the most important imports into Upper Egypt is natron from Darfour.'[9]

[1] This description was kindly communicated by Sir H. Sadek Pasha, formerly Controller, Mines and Quarries Department, Cairo.

[2] C. S. Sonnini, *op. cit.*, I, p. 324.

[3] W. G. Browne, *Travels in Africa, Egypt and Syria*, 1799, pp. 39–42.

[4] G. Schweinfurth, *Die Umgegend von Schaghab u. El-Kab (Ober-Ägypten)*, in *Zeitschrift der Gesellschaft f. Erdkunde zu Berlin* (1904), pp. 575–9.

[5] G. Schweinfurth and L. Lewin, *Beiträge z. Topographie u. Geochemie des ägyptischen Natron-Tals*, in *op. cit.*, XXXIII (1898), pp. 1–25.

[6] Somers Clarke, *El-Kâb and its Temples*, in *Journal of Egyptian Archæology*, VIII, p. 17.

[7] S. Lane-Poole, *A History of Egypt in the Middle Ages* (1901), p. 304.

[8] W. G. Browne, *op. cit.*, pp. 187–8.

[9] J. L. Burckhardt, *Travels in Nubia*, n. p. 306. See also G. W. Murray, The Road to Chephren's Quarries, *The Geographical Journal*, XCIV (1939), p. 97.

In the ancient Egyptian records the natron deposits both of the Wadi Natrun[1] and of El Kab[2] are referred to, but so far as can be ascertained the Barnugi deposit is not mentioned. In the reign of Ramesses III (1198–1167 B.C.) natron gatherers of Elephantine are named.[3] This seems a most unlikely place for natron to occur in workable quantity and there is no evidence of any to-day. In the reign of Tuthmosis III (1501–1447 B.C.) natron is enumerated among the articles of tribute received from Retenu (Syria).[4]

The classical writers, Strabo[5] (first century B.C. to first century A.D.) and Pliny[6] (first century A.D.), both mention natron deposits in Egypt. The former, in his description of a journey by boat from the coast to Memphis (apparently from Schedia by canal to the Canopic branch of the Nile and then by river) refers to two pits that furnished natron in large quantities, which he states were situated (as was also the Nitriote Nome) beyond (above, or south of) Momemphis and near to Menelaus. Then he goes on to say that on the left in the Delta was Naucratis and that at a distance of two *schœni* from the river was Sais. The question that arises is whether the natron pits were those of the Wadi Natrun or those of Barnugi. This could be settled at once if the precise position of either Momemphis or of Menelaus were known, but unfortunately the positions of these places are doubtful. Parthey,[7] Perthes[8] and Dümichen[9] all show Momemphis well south of Naucratis, and Parthey shows Menelaus south of Momemphis. If these maps are correct the natron pits must have been those of the Wadi Natrun. The evidence for assigning the positions, however, is not given, but it may have been that the Barnugi deposit was not known to these cartographers and that they therefore fixed Momemphis and Menelaus with reference to the only natron deposit with which they were acquainted, namely that of the Wadi Natrun, and if so, then to appeal to these maps is to argue in a circle. Strabo's allusion to Naucratis and Sais immediately following his mention of Momemphis and Menelaus is ambiguous, but seems to be unconnected with his reference to the

[1] H. Gauthier, *Dictionnaire des noms géographiques contenus dans les textes hiéroglyphiques*, v, p. 56. H. Brugsch, *Dictionnaire géographique de l'ancienne Égypte* (1879), pp. 150, 496–7. A. Erman, *The Literature of the Ancient Egyptians*, trans. A. M. Blackman, pp. 116, 117, 120.

[2] H. Gauthier, *op. cit.*, III, p. 99. H. Brugsch, *op. cit.*, pp. 45, 355.

[3] J. H. Breasted, *op. cit.*, IV, 148. [4] II, 518. [5] XVII: 1, 22, 23.

[6] XXXI: 46.

[7] G. Parthey, *Zur Erdkunde des alten Aegyptens* (1859), Maps i, ii, viii, xv, xvi.

[8] J. Perthes, *Atlas Antiquus* (1879), Tab. 3.

[9] J. Dümichen, *Zur Geographie des alten Ägypten* (1894), Map viii.

position of the natron pits, which, if near Naucratis, must have been those of Barnugi. This is confirmed by Butler's statement that Momemphis was close to Damanhur.[1]

With reference to Barnugi, Evelyn White wrote that 'There is strong evidence to show that Barnugi is the Coptic Pernoudj, and the latter is certainly Nitria. Barnugi then would be the modern representative of the famous Nitria (not the Wadi el Natrun). Ancient authors clearly show that natron was obtained in the N.W. Delta in the region of Naucratis—not far distant.'[2]

Pliny states[3] that in Egypt natron (*nitrum*) used to be found (*nitrariae . . . tantum solebant esse*) only near Naucratis and Memphis.[4] The position of the first-mentioned deposit would fit that of Barnugi and, if so, then by exclusion the second would be that of the Wadi Natrun, since only two deposits are known in this locality. It is true that the Wadi Natrun is not very close to Memphis, but it is difficult to believe that this important source should be ignored in favour of some small and insignificant place nearer to Memphis, even if such existed, which is doubtful. Pliny's whole account of natron in Egypt, however, is very confused and often unintelligible. The natron from near Memphis is described as being inferior to that from near Naucratis because the heaps petrify and are turned into rock, from which vessels are made; and it is further stated that the material is often melted and heated with sulphur—though for what purpose is not mentioned.

No analyses of the Barnugi natron can be traced, but it is almost certainly not so good as the best quality from the Wadi Natrun. Natron, from whatever source obtained, if stacked in heaps for a long period and exposed to occasional slight rain would become consolidated, but never very hard, and it is conceivable, though improbable, that a few small vessels might have been made as curiosities from such natron. That natron was ever heated with sulphur is highly improbable.

Pliny states, too,[3] that natron was prepared artificially in Egypt, much in the same manner as salt, the difference being that to make salt sea water was used, while to make natron the water employed was that of the Nile. From this account, which is largely wrong, and most misleading, especially in the analogy to sea water, it would seem that

[1] A. J. Butler, *The Arab Conquest of Egypt*, 1902, p. 21.

[2] Private letter to Dr. W. F. Hume, who has kindly allowed me to make use of it. See also H. G. Evelyn White, *The Monasteries of the Wadi 'n Natrun*, II (1932), pp. 17–42.

[3] XXXI: 46.

[4] White (*op. cit.*, p. 22) suggests that Momemphis is meant.

Pliny had some very confused idea of the manner in which natron occurs in Egypt, namely as a deposit in certain low-lying areas, which become flooded soon after the annual rise of the Nile, by reason of the infiltration water (either directly from the river or from canals or other sources fed by the river) that finds its way into them. The Nile water, however, does not, and never did, yield natron on evaporation.

It is suggested that the confusion may have originated in the following manner. When sea water evaporates, salt is left, and when the seepage water (either direct or indirect) from the Nile that finds its way into certain depressions evaporates, natron is left. Hence, at first sight, the two phenomena might appear to be similar, though they are fundamentally different. In the case of sea water, the salt is in solution in the water, and is left as a dry deposit when the water evaporates; whereas in the case of the Nile seepage, the natron exists not in the water, but in the low-lying ground into which the water penetrates, having slowly accumulated there as the result of chemical reactions that have taken place in the soil during the course of long ages; all that the water does is to dissolve the natron already present and to bring it to the surface, where it is left when the water evaporates. Pliny's reference to the hasty collection of the natron if rain falls, for fear it should be redissolved, is suggestive of the Barnugi deposit, rather than that of the Wadi Natrun, since in the latter the rainfall is insignificant and does not seriously affect the natron, while at Barnugi the amount of natron is less and the rainfall greater, and in the autumn, before the natron is gathered, there might be sufficient rain to flood the area that had dried during the summer and so spoil the harvest.[1]

In ancient Egypt natron was used in purification ceremonies,[2] especially for purifying the mouth[3]; for making incense[4]; for the manufacture of glass,[5] glaze, and possibly the blue and green frits used as

[1] Early rain at the Lake Mareotis salt works near Mex limits considerably the amount of available salt.

[2] J. H. Breasted, *op. cit.*, IV, 865; A. M. Blackman, *Some Notes on the Ancient Egyptian Practice of Washing the Dead*, in *Journal of Egyptian Archæology*, V (1918), pp. 118–20.

[3] A. M. Blackman, *The House of the Morning*, in *Journal of Egyptian Archæology*, V (1918), pp. 156–7, 159, 161–3. At the present time natron mixed with tobacco is chewed in Egypt.

[4] British Museum, *Introductory Guide to the Egyptian Collections* (1930), p. 5; E. A. Wallis Budge, *The Literature of the Ancient Egyptians* (1914), pp. 14, 38, 218. Natron mixed with an odoriferous gum-resin, almost certainly incense, was found in the tomb of Tut-ankhamun.

[5] The remains of ancient glass factories still exist in the Wadi Natrun.

pigments, which may be made either with or without alkali, but which are more easily made if alkali is present; for cooking[1]; in medicine[2]; for bleaching linen[3] and in mummification.[4] Natron was still being used at Alexandria for glass making as late as 1799.[5]

During the Ptolemaic period natron was a royal monopoly[6]; in Arab times it was a considerable source of revenue to the Government[7] and at the present day a small royalty is paid on all that is extracted.

As found in Egypt, natron always contains sodium chloride (common salt) and sodium sulphate as impurities, these being present in very varying and often considerable proportions[8]; thus, in 14 samples of natron from the Wadi Natrun analysed by me,[9] the proportion of common salt varied from 2 to 27 per cent and that of sodium sulphate from a trace to 39 per cent, while in three samples from El Kab the common salt varied from 12 to 57 per cent and the sodium sulphate from 11 to 70 per cent. In three samples of natron from El Kab analysed by Lewin the common salt varied from 25 to 54 per cent and the sodium sulphate from 12 to 54 per cent.[10] Natron has been found from as early as the Tasian period.[11]

Nitre

At the present time the word nitre means potassium nitrate (saltpetre) and only potassium nitrate, but the word is derived from the ancient Egyptian *ntry*,[12] which meant what is now called natron, a natural soda consisting essentially of sodium carbonate and sodium bicarbonate. In consequence of this derivation there has always been considerable

[1] According to Pliny (xxxi: 46) the Egyptians used natron for cooking radishes, and at the present day it is used to a small extent in cooking vegetables.

[2] J. H. Breasted, *The Edwin Smith Surgical Papyrus*, 1, pp. 412, 491; C. P. Bryan, *The Papyrus Ebers* (1930), pp. 18–9, 22, 56, 60, 64, 88, 100, 104–5, 115, 130, 159–60, 165.

[3] C. C. Edgar, *Papyri Zenon III*, No. 59304. Sonnini mentions the use of natron for the same purpose in his time (C. S. Sonnini, *Travels in Upper and Lower Egypt*, 1807, trans. H. Hunter, 1, pp. 321–2.

[4] See p. 317.

[5] W. G. Browne, *Travels in Africa, Egypt and Syria*, 1799, p. 10.

[6] E. Bevan, *A History of Egypt under the Ptolemaic Dynasty* (1927), p. 148.

[7] S. Lane-Poole, *A History of Egypt in the Middle Ages* (1901), p. 304.

[8] For detailed analyses, see pp. 548–9.

[9] A. Lucas, *Natural Soda Deposits in Egypt* (1912), pp. 15–6.

[10] G. Schweinfurth, *op. cit.*, pp. 575–9.

[11] G. Brunton, *Mostagedda*, p. 33.

[12] J. H. Breasted, *The Edwin Smith Surgical Papyrus*, 1, p. 412.

confusion between nitre and natron, and there is also confusion between nitre and another natural product, sodium nitrate. This confusion still persists and the *nitron* of Herodotus[1] and Dioscorides[2] and its Latin equivalent, the *nitrum* of Pliny,[3] are often wrongly translated as nitre, instead of natron, and sodium nitrate is frequently referred to as saltpetre. Thus the 'saltpetre' occurring in Sinai and used locally for making gun powder[4] and blasting powder[5] is almost certainly sodium nitrate and not potassium nitrate, the latter of which occurs, so far as is known, only in small quantity in one locality in Sinai,[6] whereas the former is much more common, being found over large areas in Upper Egypt, where it is exploited as a fertiliser for use on the crops, though whether it was employed anciently is not known. No evidence can be found that nitre (potassium nitrate) was either known or used anciently in Egypt, and where the word is employed in modern books in connexion with ancient Egypt, it is likely to be a mistranslation, as, for instance, with reference to mummification and glass making.

The Hebrew word wrongly translated 'nitre' in the book of Proverbs[7] in the Bible certainly does not mean potassium nitrate, upon which vinegar has no action, but sodium carbonate (natron), which is dissolved by vinegar with effervescence, which fact was known to Robert Boyle in 1680.[8]

Salt

Common salt (sodium chloride) occurs abundantly in Egypt. At the present time it is procured commercially in large amount from Lake Mareotis in the north-west of the Delta and from salines at Port Said, but small quantities are also obtained surreptitiously from local deposits in various places. Pliny mentions[9] a lake near Memphis from which salt, which he states was of a red colour, was extracted: he says[9] too that one of the Ptolemies found salt near Pelusium (Damietta) and that it occurred beneath the sand in the desert between Egypt and

[1] *Herodotus*, II, 86–8. (The Loeb Classical Library.)
[2] R. T. Gunther, *The Greek Herbal of Dioscorides*, V: 130, 131.
[3] XXXI: 46.
[4] G. W. Murray, *Sons of Ishmael*, p. 78.
[5] W. M. F. Petrie, *Researches in Sinai*, p. 257.
[6] F. W. Moon and H. Sadek, *Top. and Geol. of Northern Sinai*, I, p. 75.
[7] *Proverbs*, 25: 20.
[8] Robert Boyle, *Experiments and Notes about the Production of Chymical Principles*, 1680, p. 30.
[9] XXXI: 39, 41, 42.

Arabia and also in the western desert and that on the coast of Egypt there were artificial salines for the extraction of salt from sea water.

The flower of salt (*flos salis*) mentioned by Pliny[1] and Dioscorides[2] that occurred in Egypt and was supposed to float down the Nile, but was also found on the surface of the water of certain springs, has not been identified, but it was certainly not patches of petroleum coming down from the White Nile, as suggested by Bailey,[3] though there may be petroleum beneath Lake Albert and in the bed of the Kafu (a tributary of the Victoria Nile); and one has only to know the Nile in the Delta and to realize that it has travelled nearly 4,000 miles before it reaches the Delta, to be quite sure that no petroleum comes down floating on the surface or that it ever did so come down.

Herodotus says[4] that in Egypt 'the ground is coated with salt (insomuch that the very pyramids are wasted thereby)' and he mentions[4] 'salting factories' at Pelusium and the use of salt for mixing with oil for lamps.[4]

A small aggregate of salt crystals, which I analysed and found to be very pure and free from natron and sodium sulphate, found at Gebelein in a box of Sixth Dynasty date,[5] and two bricks of salt (20 × 11 × 3 cm. and 19 × 9 × 4 cm. respectively), unfortunately undated, from Deir el Medineh[6] are in the Cairo Museum. I have also examined two large lumps and several small lumps of salt of Eighteenth Dynasty date found by Bruyère at Deir el Medineh.

Salt, in addition to its use as a seasoning for food, was largely employed in ancient Egypt for preserving fish. The question of its use in mummification will be dealt with in connexion with that subject.[7] Salt was a royal monopoly in the Ptolemaic period.[8]

SULPHUR

Sulphur occurs native in most volcanic districts and also, and usually in large quantities, associated with gypsum and it is in this latter connexion that it is found in Egypt: it occurs on Ras Jemsa (where it has been extensively worked in modern times); at Bir Ranga and at Ras

[1] XXXI: 39, 41, 42. [2] V: 129.
[3] K. C. Bailey, *The Elder Pliny's Chapters on Chemical Subjects*, I, p. 168.
[4] II: 12, 15, 62. [5] No. J. 66842. [6] No. J. 38646.
[7] See p. 313.
[8] E. Bevan, *A History of Egypt under the Ptolemaic Dynasty*, p. 149.

Benas, all on the Red Sea coast.[1] Small fragments of sulphur are also found occasionally in the limestone near Cairo[1] and it is deposited from the warm ' sulphur ' springs at Helwan.

Sulphur has been found on several occasions in connexion with ancient Egypt, for example, several small pieces, weighing altogether about 6.5 grams, dating possibly from Roman times were found by Brunton[2]; a small piece of about the Twenty-sixth Dynasty date was discovered by Petrie at Defenneh,[3] and thirty-five small rosettes, nineteen bull-head amulets and four Bes-head amulets of sulphur of unknown, but probably late, date were purchased by the Cairo Museum.[4] The Roman specimens showed signs of having been melted. The most likely source of the material is the Red Sea coast.

[1] W. F. Hume, *Explan. Notes for the Geol. Map of Egypt*, pp. 40–1.
[2] G. Brunton, *Qau and Badari*, III, p. 34.
[3] W. M. F. Petrie, *Nebesheh and Defenneh*, p. 75.
[4] Nos. J. 71593 A, B, C. L. Keimer, Perles de collier en soufre fondu, *Annales du Service*, XXXIX (1939), pp. 203–8.

CHAPTER XII

MUMMIFICATION

The earliest method of disposal of the dead in Egypt was burial in the ground, which goes back to the neolithic period, neither bodies, nor graves, if ever there were graves, from the still older paleolithic period having yet been found.

In a hot climate like that of Egypt, if a grave is a shallow one in porous sand, situated well above the maximum subsoil water level, the sand becomes intensely hot in the sun, and the body moisture slowly evaporates and escapes through the sand, and eventually the body is left dry, practically sterile, and in such a condition that it will last almost indefinitely if kept dry. Simple burial, therefore, in a shallow grave in the desert is an excellent method of preserving the body, though if the grave is too near the surface, or not protected in some manner, as, for instance, by stones, the body may be dug up by wild animals, such as hyenas and jackals.

During the neolithic and predynastic periods, the body was buried in a shallow grave, situated at the edge of the desert just beyond the cultivation, generally wrapped in an animal skin or loose folds of linen, but by the early dynastic period the graves of the kings and wealthier classes had become deeper, were lined with sun-dried mud bricks, or with wood, and often were covered with a superstructure; and the previous loose covering on the body had given place to close-fitting linen wrappings, which in some instances eventually became elaborated into the separate wrapping of each limb, with further wrappings for the whole body, examples of which are known from the First,[1] Second[2] and Third[3] Dynasties respectively, before mummification was introduced.

Concurrently with the covering of the body with a greater number and more elaborate wrappings and with its burial in a larger and

[1] W. M. F. Petrie, *The Royal Tombs*, II, p. 16.

[2] J. E. Quibell, *Excavations at Saqqara* (*1912–1914*), pp. 11, 19, 28, 32, Pl. XXIX (3).

[3] D. E. Derry, (*a*) *The Step Pyramid* (C. M. Firth and J. E. Quibell), pp. 100–1; (*b*) *Annales du Service*, XXXV (1935), pp. 28–30; XLI (1942), pp. 240–6.

deeper grave, what were thought to be additional means of protection were introduced, which included the enclosing of the body at first in a wooden coffin, and later also in a wooden or stone sarcophagus, until the culmination was reached, which is represented in the case of kings in the tomb of Tut-ankhamun (mummification, sixteen layers of linen wrappings, three coffins, a stone sarcophagus and four shrines), by whose reign manifestly it had become conventional. But, long before this time, on account of the deepening and elaboration of the grave, and with each addition to the wrappings, coffins and other fancied means of protection, the desiccation of the body must have been more prolonged, and its preservation, therefore, less perfect, and, since the religious belief regarding a future life now demanded that the body should last for all time, a preservative method of treatment before burial became necessary, and, therefore, was employed, this process being what is known as embalming or mummification.

The word embalm is derived from the Latin *in balsamum*, meaning to preserve in balsam, or balm, which it actually was. The word mummy probably came from a Persian word *mummia*, signifying bitumen, and it was applied at a late date to the embalmed bodies of the dead in Egypt, owing to the mistaken idea that because the body so preserved was black and looked as though it had been soaked in bitumen, therefore, the preservative agent employed must always have been bitumen, which, however, was not so, though in one mummy of the Persian period bitumen has been found.[1] In many other mummies of this period, which I have examined, there has not been any evidence of bitumen.

Since the ancient Egyptians believed that the spirit, which had left the body at death, would return and be re-united to the body, it was of the utmost importance, not only that the body should be preserved, but also that it should be kept in as lifelike a condition as possible, and these, therefore, were the main objects of mummification, the means adopted for carrying them out, and the success attained, varying at different periods.

At what date mummification was first practised is unknown, but the first definite evidence of it is from the beginning of the Fourth Dynasty, from which period there is the Canopic Box of Queen Hetepheres (mother of Cheops, the builder of the great pyramid at

[1] Ahmed Zaki and Zaki Iskander, Materials and Methods Used for Mummifying the Body of Amentefnekht, Saqqara, 1941, *Annales du Service*, XLII (1943), pp. 223–50.

Giza), which contains packets wrapped in linen of what are almost certainly the viscera, immersed in what I have analysed and found to be a dilute (approximately three per cent) solution of natron, containing the usual impurities of sodium chloride and sodium sulphate.[1] This seems to be proof that the body also had been preserved, although the sarcophagus, which should have contained it, was empty, the mummy most probably having been taken out and destroyed by tomb robbers searching for the jewellery with which the queen had been buried. There was an Egyptian mummy in the Museum of the Royal College of Surgeons, London,[2] of Fifth Dynasty date, which was destroyed during an air raid in 1941, from which dynasty onwards mummification continued to be practised until the early Christian period, though for long after its introduction it was restricted to kings, the royal family, nobles, priests, high officials and the wealthy classes, and it was not until much later that mummification became general and that the poorer classes also were embalmed.

The only practical methods by means of which human bodies can be preserved indefinitely are:

1. By cold storage, which was unknown anciently in Egypt.

2. By the modern method of injecting into the blood vessels some fluid having germicidal and antiseptic properties, which diffuses slowly into the tissues and so preserves them. This also was unknown anciently.

3. By drying the body thoroughly and afterwards keeping it dry, which is what the ancient Egyptians did, desiccation being the essential preliminary treatment to mummification.

Since about 75 per cent of the human body by weight consists of water, to dry it thoroughly is not an easy matter, but there are two methods by which this may be done, one by heat, either the natural heat of the sun or the artificial heat of a fire, and the other by the use of a drying (dehydrating) agent, which will abstract and absorb the water. Drying such a bulky object, and one containing so much water as the human body, by exposure to the sun would be a very slow process, even in Upper Egypt, and still slower in Lower Egypt, where there are many sunless days and even some wet days, and to have buried the bodies and to have dug them up after several years

[1] G. A. Reisner, *Bull. Museum of Fine Arts, Boston*, XXVI (1928), pp. 80–1.

[2] G. Elliott Smith and Warren R. Dawson, *Egyptian Mummies*, pp. 74–5. This I examined and the body was coated with resin and wrapped in resin-soaked bandages. See also W. M. F. Petrie, *The Funeral Furniture of Egypt*, pp. 16–7.

when they were thoroughly dried, in order to put them into coffins and tombs, would have been very expensive and would have required such a detailed organization to ensure correct identification and to prevent confusion that it would have been impracticable on a large scale, and there is not the slightest evidence that any natural method of drying was ever employed deliberately, and the alternative, therefore, was an artificial method, which, as already stated, theoretically might have been either by means of the heat from a fire or by chemical desiccation.

It is sometimes suggested that the bodies of the dead were dried by artificial heat. Thus Royer says[1] '*Il est certain que les embaumeurs . . . les plaçoient dans des étuves*,' and Dawson thinks[2] that it is 'probable that fire-heat was used, through the medium of some apparatus of which we at present have no information.' He also says[3] 'considerable heat must have been required to remove the moisture absorbed during their long immersion in salt water. We do not know, however, whether this was done by the heat of the sun, or by fire; probably both methods were employed . . .' During the Mond excavations in the necropolis of Thebes a chamber was found in the tomb of a certain Hatiay, 'where a vast number of dried mummies were piled up almost to the ceiling'[4] and Yeivin, who was associated with the work, states[4] that 'the mummies, to judge from their appearance, seem to have been dried over a slow fire, which would explain the smoky appearance of all the chambers and passages above.' What there was about the mummies to suggest fire-drying is not mentioned. The mere fact of so many mummies being together in one tomb seems to be strong evidence against this having been the place where they had been prepared, for it is difficult to believe that a large number of people should have handed the bodies of their relatives to the embalmers and, in the absence of any general cataclysm, should never have reclaimed them.

The piling together of numbers of mummies in one tomb has often been reported, and Rouyer says[5] '*on trouve des milliers de momies*

[1] P. C. Rouyer, Notice sur les embaumemens des anciens Égyptiens, *Description de l'Égypte, Antiquités, Mémoires*, I, (1809), pp. 209, 212. Rouyer says that *natrum* was obtained from several lakes in Egypt, where it occurred abundantly as '*carbonate de soude*'.

[2] W. R. Dawson, *Journal of Egyptian Archaeology*, XIII (1927), p. 45.

[3] W. R. Dawson, Contributions to the History of Mummification, *Proc. Royal Society of Medicine*, XX (1927), p. 851.

[4] S. Yeivin, Liverpool *Annals*, XIII (1926), p. 15.

[5] P. C. Rouyer, *op. cit.*, p. 214.

entassées les unes sur les autres'; Pettigrew states[1] that Captain Light 'found thousands of dead bodies placed in horizontal layers side by side'; Rhind states[2] that 'bodies of the humbler classes were, at Thebes, deposited in large catacombs . . . and piled together to the number, it is said, of hundreds'; Belzoni states[3] that one place 'was choked with mummies' and again[3]: 'Thus I proceeded from one cave to another all full of mummies piled up in various ways,' and Wilkinson explains[4] that 'mummies of the lower orders were buried together in a common repository.'

That the tomb described by Yeivin was smoke-blackened is no proof that the smoke was that from a fire used to dry human bodies, and there is ample evidence that such blackening of tombs, which is not uncommon, is generally due to one of several causes, namely, to the tomb having been occupied as a dwelling; to the use of smoky torches by robbers or sightseers, or to other reasons. Thus, on one occasion, in comparatively recent times, when certain tombs in the Theban necropolis were occupied by bands of robbers, the authorities killed the robbers by filling the mouths of the tombs with dry brushwood, which was then set on fire.[5] Jomard in 1809 mentions an accidental fire in a tomb, the walls of which were thereby blackened.[6] Davies suggests[7] that sometimes tombs were purified by fire. Not only in this case, but also in all others, there is a complete absence of evidence for the drying of human bodies in ancient Egypt by artificial heat. Such a method would have been very expensive on account of the great scarcity of fuel in the country, besides which it was not necessary, since perfect desiccation may be obtained by means of a dehydrating agent. The drying of the body is not mentioned either by Herodotus or by Diodorus in their accounts of the methods employed for embalming.

There are three common and cheap dehydrating agents, namely, quick lime, common salt and natron, which will now be considered.

[1] T. J. Pettigrew, *A History of Egyptian Mummies*, p. 40.
[2] A. H. Rhind, *Thebes, its Tombs and their Tenants* (1862), p. 132.
[3] G. Belzoni, *Operations and Recent Discoveries in Egypt and Nubia* (1820), p. 157.
[4] J. G. Wilkinson, *The Manners and Customs of the Ancient Egyptians*, II, p. 400.
[5] J. Bruce, *Travels to Discover the Source of the Nile*, II, 2nd ed., 1805, p. 33.
[6] E. Jomard, Description des hypogées de la ville de Thèbes, *Description de l'Égypte*, 1809, I, p. 317.
[7] N. de G. Davies, *The Tomb of Menkheperrasonb, Amenmose and Another*, pp. 18–20, 24, 27, 28.

Lime

The use of lime in mummification was suggested by Dr. A. B. Granville,[1] who thought it had been employed to remove the epidermis. which Pettigrew supposed[1] was done in order that the palm wine mentioned by Herodotus and Diodorus (which, however, according to these writers was only used for washing the viscera and not for the outside of the body) might act more readily upon the deeper layers of the skin, but the only evidence adduced in support of the use of lime is that in a certain mummy, from which the epidermis was missing, Granville found ' traces of lime '. Since, however, calcium carbonate (carbonate of lime) in small proportion is a common impurity of Egyptian natron, this might well have been the source of the ' lime ' found.

Dr. Paul Haas, having found a small proportion of calcium carbonate (8.6 per cent if calculated from the lime shown in the analysis) in a Twelfth Dynasty mummy, concluded that ' it would seem reasonable to suppose that the lime, which is at present combined in the form of carbonate, must have been originally added in the form of quicklime . . .'[2] Dr. Margaret Murray, summarizing Dr. Haas's chemical results, accepts this use of lime.[3] Since, however, the rock-cut tomb in which the mummy in question was buried was of limestone and was situated in a limestone district, and, since almost certainly the coffins (there were two, one inside the other) were first opened where they were found, contamination with limestone dust, either at the time of burial or when the coffins were opened, is not impossible, though it seems much more probable that such contamination took place during mummification before the body was wrapped up, or still more likely that the calcium carbonate may have been present in the natron used. Moreover, another mummy from the same tomb showed only 1.6 per cent of calcium carbonate, which, unless the reasonable explanation offered that one body, or one lot of natron, but not the other, was contaminated with limestone dust (the bodies were buried at an interval of several years) be accepted, must mean that two different methods of mummification, one with lime, and the other without lime, were employed, which is most improbable.

[1] T. J. Pettigrew, *A History of Egyptian Mummies*, p. 62.
[2] M. A. Murray, *The Tomb of Two Brothers*, p. 46.
[3] M. A. Murray, *op. cit.*, p. 51.

Dr. F. Wood Jones seems to consider the use of lime possible, since he says[1] 'The epidermis, that was removed, either intentionally by the action of lime . . . or accidentally . . .'

There is not, however, the slightest evidence or probability that lime was ever used in mummification, and, so far as is at present known, lime was not employed for any purpose whatever in ancient Egypt until the Ptolemaic period.[2]

Salt

Salt was used in ancient Egypt from a very early period for preserving fish, and, since it is very abundant, and very effective as a drying agent, it seems, from theoretical considerations, a likely material to have been used in mummification, but there is no evidence that it ever was so employed (except inadvertently as an impurity in natron) until early Christian times, and then not to the best advantage, but only in comparatively small amount often placed, not in contact with the body, but outside the clothes or wrappings, or between their different layers, where any drying effect must have been negligible, and its use may have been ritualistic, or conventional, rather than practical. However, in spite of considerable evidence to the contrary, it is still frequently stated that salt was employed for embalming. Thus Schmidt states[3] very emphatically that salt was used and not natron; Elliot Smith says[4] 'There can, however, be no doubt that the body and viscera were primarily treated . . . by being immersed . . . in a bath of chloride of sodium'; Elliot Smith and Warren Dawson say[5] 'It can be confidently stated that at most periods common salt (mixed with certain natural impurities) was the essential preservative material employed by the Egyptians for embalming' and Dawson states[6] that 'In general terms it may be said that for the immersion-bath common salt (mixed with various impurities) and not natron was used.' What the various natural impurities with which the salt was mixed consisted

[1] F. Wood Jones, The Arch. Survey of Nubia, Report for 1907–1908, *Report on the Human Remains*, p. 200.

[2] See p. 93.

[3] W. A. Schmidt, Chemische u. biologische Untersuchungen v. ägyptischen Mumien-material, etc., *Zeitschr. f. allgem. Physiol.*, Bd. VII (1907), pp. 369–72.

[4] G. Elliot Smith, A Contribution to the Study of Mummification in Egypt, *Mém. de l'Inst. Egyptien*, V (1906), p. 18.

[5] G. Elliott Smith and Warren Dawson, *Egyptian Mummies*, p. 168.

[6] Warren R. Dawson, *Journal of Egyptian Archaeology*, XIII (1927), p. 49.

of is not stated, but if one of them was natron, then to call the material common salt is incorrect and misleading.

Egyptian natron always contains salt and often in considerable proportion, one specimen from El Kab analysed by me containing as much as 57 per cent, but this is exceptional and this particular specimen had no connexion with embalming and is not representative of the bulk of the natron from El Kab, another specimen of which contained only 12 per cent of salt, and much less is it representative of that from the Wadi Natrun, where the highest proportion of common salt in fourteen samples analysed by me was 27 per cent[1] and the lowest 2 per cent. To contend that the material employed in mummification, although nominally natron, was actually common salt would be fallacious, and if the mere presence of impurities, such as common salt and sodium sulphate, in Egyptian natron makes it reasonable to deny to it the name of natron, then there is no natron in Egypt, and it becomes absurd to speak of natron, or of the Wadi Natrun, or other natron deposits.

The facts respecting salt and mummies, so far as they have been placed on record, and so far as they can be traced, are as follows: In a Twelfth Dynasty mummy Dr. Paul Haas found 1.89 per cent of chlorine[2] representing 4.8 per cent of common salt, whereas in a second mummy from the same tomb, and of nearly the same date, there was only 0.22 per cent. of chlorine, which represents 0.6 per cent of salt. The difference in salt content of these two mummies may be accounted for reasonably by assuming either the use of a different quality of natron in the two cases (there is a definite evidence of the use of natron in one case), one lot containing more salt than the other (there was an interval of several years between the two burials), or by the use in one instance of a more salty water for washing the body than in the other.

A few tiny crystals of salt were found on the skin on the top of the shoulders of the mummy of Tut-ankhamun (Eighteenth Dynasty), and a very small aggregate of tiny salt crystals was also found inside the gold coffin at the head end.[3] The total amount of salt was so small that it cannot have been derived from the use of salt, and it is

[1] Natron bought locally, which probably was from the Wadi Natrun, though this is not certain, contained 29 per cent of salt.

[2] M. A. Murray, *The Tomb of Two Brothers*, p. 47.

[3] D. E. Derry, Appendix I, *The Tomb of Tut-ankh-Amen*, Howard Carter, II, p. 152.

even unlikely that it came from the use of natron containing salt, and it seems much more probable that it originated in the water used for washing the body before it was wrapped up. Although the water from the Nile at Elephantine was esteemed the most efficacious for this purpose, it is improbable that it was always used, and, if not, then the alternative would have been water from the river locally, from a sacred pool,[1] or from the sacred lake of a temple, or well water, the last three of which might have contained a considerable proportion of salt.

Elliot Smith states[2] that the mummy of Meneptah (Nineteenth Dynasty) was 'thickly encrusted with salt.' This mummy, which is in the Cairo Museum, I have examined specially with the following results: The skin, which is mostly of a light brown colour, is very patchy and mottled, the patches consisting of a number of areas, some of considerable size, that are white, and the mottling taking the form of numerous small raised spots, practically the same colour as the skin, covering the chest and abdomen and occurring also on the forehead, and having the appearance of an eruption. Neither the white patches nor the mottling is salt. Salt, however, is present, but in very small amount, most of it being invisible to the naked eye, though there are a few very small areas where there are efflorescences of tiny salt crystals, so minute that they can only just be seen without a lens. The total amount of salt present is so small that it might have been derived from the use of natron containing salt, or from the use of salty water for washing, and probably was so derived.

With respect to a Seventeenth Dynasty mummy, Elliot Smith writes[3] 'I submitted a piece of skin to Professor W. A. Schmidt . . . but he was unable to find any excessive quantity of salt in it, in fact no greater quantity of sodium chloride than the normal tissues of the body contain.' The skin was 'soft, moist, flexible.'

There was a small proportion of salt in the resin from the mummy of Nesikhonsu (Twenty-first Dynasty) examined by me,[4] which, again, might have been derived from the water used in washing.

Salt was also found by me in a Coptic mummy (fifth century A.D.) from Naga el Deir[4]; on bodies of early Christian date from near

[1] A. M. Blackman, *Proc. Soc. Bibl. Arch.*, XL (1918), pp. 61–4.

[2] G. Elliot Smith, (*a*) *The Royal Mummies*, p. 67; (*b*) *Annales du Service*, VIII (1907), p. 111.

[3] G. Elliot Smith, *The Royal Mummies*, pp. 1, 9.

[4] A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, pp. 19, 20.

Aswan, the wrappings of which were ' very heavy and sticky with salt,' [1] a number of specimens of which I analysed, and on certain mummy tissues examined by Schmidt, who states[2] that the authentic embalmed material was largely impregnated with salt, in many cases the interiors of the mummies being entirely covered with salt crystals, the Coptic mummies containing the most salt, in one instance 8.5 per cent being present in the arm muscles. Ruffer, commenting on this, writes[3] ' These observations of Schmidt have not been confirmed so far, and are all the more remarkable because Coptic mummies (so-called) show no incision; salt has been placed on the integuments, and it is difficult, if not impossible, to understand how under such circumstances the quantity of salt mentioned by Schmidt can have penetrated into the muscles. I have seen the inner surface of the body cavities—the muscles, liver and other organs—of Coptic mummies covered with white crystals, but these were crystals of fatty acids and not salt.[4] The mummies, which I have examined often, contained inside the wrappings lumps of common salt; and in one case a lump of sodium chloride about the size of a fist was lying on the anterior surface of the abdomen; but it appears to me very doubtful whether much salt had been used, as the wrappings had not been infiltrated with visible crystals of salt, and analysis did not reveal any abnormal quantity of salt in the skin or muscles.'

During early Christian times many of the bodies on which salt has been found, although called mummies, even by archaeologists, were not mummified, and, therefore, may be left out of account in the present discussion, for example, the Coptic body from Naga el Deir mentioned, although called a mummy in the description that accompanied the specimen of salt received for analysis, almost certainly had not been mummified.

An embalmer's swab,[5] made of linen tied to the end of a small stick, of unknown but late date, found by Winlock at Thebes and examined by me contained a trace of salt, but no natron. A trace of salt, however, is of no significance in Egypt and might have come from the water used with the swab, or from the ground on which it was lying.

[1] G. A. Reisner, *Arch. Survey of Nubia, Report for 1907–1908*, p. 100.
[2] W. A. Schmidt, *op. cit.*, pp. 369–72.
[3] Sir Armand Ruffer, The Use of Natron and Salt by the Ancient Egyptians, *Cairo Scientific Journal*, IX (1917), pp. 43–4.
[4] These were analysed by me. See A. Lucas, *op. cit.*, p. 55.
[5] Cairo Museum, No. J. 56290.

A wooden object,[1] possibly an embalmer's tool, of Twelfth Dynasty date, found by Lansing at Lisht, also examined by me, showed a trace of salt and also patches of oil, but no natron. Here again a trace of salt in no way proves the use of salt in embalming.

An ankh sign of Twelfth Dynasty date, made of thin vegetable fibre, found by Daressy in a sarcophagus at El Bersha[2] is thickly encrusted with large salt crystals, an indication that at one time it was immersed in a strong salt solution, which slowly evaporated, for in that manner alone could the large crystals have been formed, but where it acquired the salt there is no evidence to show, and certainly no evidence that it was in connexion with embalming.

Salt, apart from that contained as an impurity in natron, has never been discovered among refuse embalming material (of which many deposits have been found), nor, if the ankh sign is excepted, in any manner suggestive of its use in embalming; the only instances where salt has been found from ancient Egypt are enumerated elsewhere.[3]

Natron

Solid natron has been found in connexion with ancient Egypt as follows:

1. In vases and jars in tombs. Examples: (*a*) in the tomb of Yuya and Thuyu (Eighteenth Dynasty).[4] This was refuse embalming material, since it was ' wrapped up in bits of cloth ' contained in fifty-two large jars, and in one instance at least it was a mixture of natron and sawdust; (*b*) in ten large jars in the tomb of Maherpra (Eighteenth Dynasty),[5] which also was refuse embalming material, as it was mixed with resin and sawdust; (*c*) in the tomb of Tut-ankhamun (Eighteenth Dynasty).[6] In this tomb a vase containing natron was in the same ' kiosk ' as another vase containing resin, and this probably had a direct connexion with embalming. Another specimen of natron was mixed with an aromatic gum-resin, almost certainly incense, while two other specimens were in a special form of alabaster stand placed in front of

[1] Cairo Museum, No. J. 63874.

[2] Cairo Museum, No. J. 32867. G. Daressy, *Annales du Service*, XI (1910), p. 40.

[3] See p. 305.

[4] J. E. Quibell, *The Tomb of Yuaa and Thuiu*, pp. 75–7. The analyses of some portions of this material submitted by Mr. Quibell were made by me.

[5] Lortet and Gaillard, *La faune momifiée de l'ancienne Égypte*, I, pp. 317–8.

[6] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 32; III, pp. 39, 46. A. Lucas, Appendix II, *The Tomb of Tut-ankh-Amen*, III, pp. 178–9.

the canopy covering the canopic box; (*d*) in an Eighteenth Dynasty tomb at Thebes[1]; (*e*) in the Ramesseum (Nineteenth Dynasty) together with woven fabric[2]; (*f*) in a Twenty-first Dynasty tomb at Saqqara.

2. In packages in tombs. Describing the tomb of Meryet-Amun at Thebes (Eighteenth Dynasty) Winlock says[3] 'Natron . . . seems to have been placed in the tomb as well. Small lumps of it, dumped out of their proper receptacles, had been swept up into basket B.' Wainwright found natron in a Twenty-fifth Dynasty tomb at Kafr Ammar.[4]

3. Buried in pits with refuse embalming material. At least ten lots, some of which were analysed by me, were found by Winlock at Deir el Bahari, ranging from the Eleventh to the Thirteenth Dynasty.[5]

The refuse embalming material, either from the embalming of Tut-ankhamun, or from the embalming of the two children whose mummies were found in the tomb, was found about ten years before the tomb was discovered, and among it were 'small bags containing a powdered substance,'[6] which later was found to be natron.[6] Three lots of similar material were found by Lansing at Deir el Bahari, two of which were not dated, the third probably being of the Saite period.[7] Lansing and Hayes found at Deir el Bahari 'jars packed in sawdust, natron and linen wadding' of Eighteenth Dynasty date.[8] Naville found in the temple of Deir el Bahari 'pots containing nitre,'[9] and also 'several large jars, some of which were filled with chopped straw for stuffing the mummies, while others contained numbers of little bags of nitre or some salt used in mummification.'[9] The so-called nitre was almost certainly natron.

[1] Analysed by me. No details were given except the date and place where found.

[2] J. E. Quibell, *The Ramesseum*, p. 4.

[3] H. E. Winlock, *The Tomb of Meryet-Amun at Thebes*, pp. 11, 46.

[4] G. A. Wainwright, *Heliopolis, Kafr Ammar and Shuraja*, W. M. F. Petrie, and Others, p. 35; Pl. XXIX.

[5] H. E. Winlock, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1921–1922*, p. 34; *op. cit., 1923–1924*, pp. 31–2; *op. cit., 1927–1928*, pp. 25–6.

[6] T. M. Davis, *The Tomb of Harmhabi and Touatankhamanou*, p. 3; Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 98; III, pp. 88–9; H. E. Winlock, Materials Used at the Embalming of King Tut-ankh-Amun, *Paper No. 10, Met. Mus. of Art, New York*, 1941.

[7] A. Lansing, *Bull Met. Mus. of Art, New York, Egyptian Exped. 1916–1919*, p. 12.

[8] A. Lansing and W. C. Hayes, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1935–1936*, p. 23.

[9] E. Naville, *The Temple of Deir el Bahari*, II (1896), p. 16.

The examples above-mentioned, which are all that can be traced, are from the Theban necropolis and they vary in date from the Eleventh Dynasty to the Persian period.

4. Encrusting a wooden embalming table and four wooden blocks belonging to it[1] that were doubtless used for supporting the body; also encrusting four wooden ankh signs and a wooden object connected with embalming.[2] These objects, which are all of Eleventh Dynasty date, were found by Winlock at Thebes and are now in the Cairo Museum, where I have examined them. The table and the wooden object have resin adhering to them in addition to natron.

5. On certain mummies, examples being (*a*) a body of Middle Kingdom date found at Saqqara, where 'in the cavity of the chest were nodules of natron, about 10 of them . . .'[3]; (*b*) impregnating the tissues of a Twelfth Dynasty mummy[4]; (*c*) in two packets attached to the mummy of an unknown woman found in the tomb of Amenophis II (Eighteenth Dynasty). In one of the packets there was a mass of epidermis and in the other were portions of the viscera, in both cases mixed with solid natron,[5] which was identified by me; (*d*) impregnating the brain of the mummy of a boy from the tomb of Amenophis II[6]; (*e*) impregnating the resin from the cheeks, mouth, arm, and ribs of certain mummies of the Eighteenth and Twentieth Dynasties respectively[6]; (*f*) as small white crystals on a mummy probably of Twentieth Dynasty date in the Leeds Museum, which was analysed and found to consist 'almost entirely of carbonate of soda, with some muriate and sulphate,'[7] which is natron. Also on the bandages from the same mummy; (*g*) covering an anonymous mummy from Deir el Bahari[8];

[1] H. E. Winlock, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1921–1922*, p. 34, Fig. 33. Other embalming tables and mats have been found, but there is no evidence of natron on them. H. E. Winlock, (*a*) *Annales du Service*, xxx (1930), pp. 102–4; (*b*) *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1923–1924*, p. 32; *op. cit., 1927–1928*, pp. 25–6.

[2] The ankh signs and the wooden object have unfortunately been cleaned since I tested them, probably under the mistaken idea that the encrusting material was extraneous dirt.

[3] J. E. Quibell and A. G. Hayter, *Excavations at Saqqara, Teti Pyramid North Side*, p. 12.

[4] M. A. Murray, *The Tomb of Two Brothers*, p. 47.

[5] G. Elliot Smith, *The Royal Mummies*, p. 82.

[6] A. Lucas, *Preservative Materials Used by the Ancient Egyptians in Embalming*, pp. 13–9.

[7] W. Osborn, *An Account of an Egyptian Mummy Presented to the Museum of the Leeds Philosophical and Literary Society*, 1828, pp. 8, 44.

[8] Mathey, *Bull. de l'Inst. Égyptien*, VII (1886), pp. 186–95.

(*h*) as minute crystals on both the exterior and interior surfaces of a mummy examined by Granville, which were proved by analysis to consist of 'carbonate, sulphate, and muriate of soda,' mixed with potassium nitrate and traces of lime,[1] that is to say natron containing the usual impurities.

6. Mixed with fatty matter in certain mummies. Examples: (*a*) on the body of Tuthmosis III (Eighteenth Dynasty)[2]; (*b*) on the body of Merneptah (Nineteenth Dynasty),[3] and (*c*) in the mouth and body cavities of certain mummies of the Twenty-first and Twenty-second Dynasties.[3, 4] The material was examined by Schmidt, who, in his original paper, attributed the fatty matter to butter that had been mixed with natron, and this is still quoted, although in a later paper[5] Schmidt stated very definitely that, as the result of further work, he had changed his opinion and that he believed the fatty matter to have been derived from the body; (*d*) from the pelvis of a female mummy called 'Mummy No. 1' found in the tomb of Amenophis II (Eighteenth Dynasty, the fatty matter having probably been derived from the body.[6]

Not only was natron employed in the solid state, but it was also sometimes used in the form of a solution, and such a solution has been found on two occasions, once by Brunton[7] in an alabaster canopic jar from a royal tomb of the Twelfth Dynasty at Lahun, in which, however, there were no viscera, and once by Reisner[8] in three compartments of the alabaster canopic box of Queen Hetepheres (Fourth Dynasty), the remaining compartment being dry, owing to leakage from a defect that exists in that particular corner of the box. This natron solution, which was analysed by me, is approximately of 3 per cent strength and contains the usual impurities of Egyptian natron, namely, common salt and sodium sulphate. In each compartment of the box is a flat package wrapped in woven fabric (presumably linen) that almost certainly contains viscera.

[1] T. J. Pettigrew, *A History of Egyptian Mummies*, p. 62.
[2] G. Elliot Smith, *The Royal Mummies*, p. 32.
[3] G. Elliot Smith, (*a*) *The Royal Mummies*, p. 67; (*b*) *Annales du Service*, VIII (1907), p. 111.
[4] W. A. Schmidt, *op. cit.*, pp. 369–72. See also G. Elliot Smith, *The Royal Mummies*, pp. 99–103.
[5] W. A. Schmidt, Über Mumienfettsäuren, *Chemiker-Zeitung* (1908), No. 65.
[6] A. Lucas, *Preservative Materials Used by the Ancient Egyptians in Embalming*, p. 7.
[7] G. Brunton, *Lahun*, I (1920), p. 20. Analysed by me.
[8] G. A. Reisner, *Bull. Museum of Fine Arts, Boston*, XXVI (1928), p. 81.

There is, therefore, a considerable amount of proof that natron was employed in mummification from certainly as early as the Fourth Dynasty to as late as the Persian period, and Herodotus, writing in the fifth century B.C., states that it was used in his day.

The reason for employing natron and not salt, which latter would have been equally good, if not better, as a dehydrating agent and which was more plentiful and, therefore, cheaper than natron, was undoubtedly because natron was regarded as the great purifying agent, probably because it cleanses by chemically destroying fat and grease and, therefore, purifies in a manner that salt cannot do, and hence it was natron and not salt that was employed in all purification ceremonies, for example in lustration and in the purification of the mouth, and it was also mixed with incense with the same idea, and the embalmer's workshop was called 'The Place of Purification.'[1, 2]

Manner in which Natron was Used

The next point for consideration is the manner in which the natron was used. Until I ventured to query the generally accepted explanation, it was always stated that the natron was employed in the form of a solution, that is as a bath, in which the body was soaked, apparently largely because certain translators of Herodotus incorrectly state or infer that a solution was used. At what date the idea of a bath originated it is unnecessary and profitless to enquire, but it certainly dates from Pettigrew's time (1834) and was accepted by him, since not only does he repeatedly refer to a bath, but he quotes[3] a translation of Herodotus' description of embalming, in which it is stated that in the first of the three methods described 'they steep the body in *natrum*,' which can only mean in a solution, and that in the second method they 'lay the body in brine,' again meaning a liquid, brine being a strong salt solution. In the third method the statement is merely that 'they salt the body,' which is suggestive of the use of dry salt, rather than a solution. In a rendering by Elliot Smith and

[1] A. M. Blackman, Article, Purification (Egyptian), *Hastings's Ency. of Religion and Ethics*, X, p. 476; *Journal of Egyptian Archaeology*, V (1918), pp. 118–20, 156–63; *Recueil de travaux*, XXXIX (1921), p. 53.

[2] E. A. Wallis Budge, *The Liturgy of Funerary Offerings*, 1909, pp. 155–7, 207–9.

[3] T. J. Pettigrew, *op. cit.*, p. 46.

Warren Dawson of the passages in Herodotus relative to embalming it is stated[1] with respect to all three methods that they ' soak ' the body ' in natron,' which can only mean in a solution of natron. But the translations of Herodotus by Rouelle (1750), Rouyer (1809), Wilkinson (1841), Rawlinson (1862) and Godley (1926) respectively make no mention or suggestion of a bath or solution. According to Rouelle,[2] in the first method ' *ils salent le corps en le couvrant de natrum* '; in the second method ' *on sale le corps*,' and in the third method ' *on met le corps dans le nitre*.' Rouyer's translation[3] is identical with that of Rouelle, except that for the third method he uses the word *natrum* in place of nitre. Both Rouelle and Rouyer, however, not only translated Herodotus correctly, but realized that the underlying principle of the process described was essentially one of desiccation. Thus Rouelle says ' *les embaumeurs égyptiens ne saloient donc le corps avec le natrum que pour le dessécher* '; ' *ces momies . . . ont été simplement desséchées en les salant avec le natrum* '; of a certain mummy he is describing he states ' *le corps a été simplement desséché par le natrum* '; and ' *ils enlevoient toutes les différentes liqueurs & les graisses aux cadavres par le moyen du sel alkali & . . . par ce moyen ils desséchoient si fort qu'il ne restoit que les parties fibreuses . . .*'; and Rouyer states ' *et qu'ils soumettoient ensuite les corps . . . à l'action des substances qui devoient en opérer la dessiccation*.'

According to Wilkinson,[4] in the first method ' they salt the body, keeping it in natron '; in the second method ' they keep it in salt ' and in the third method ' they . . . salt it.'

According to Rawlinson,[5] in the first method ' the body is placed in *natrum* '; in the second method the body is ' laid in *natrum* ' and the third method is to ' let the body lie in *natrum*.'

According to Godley,[6] in the first method ' they conceal the body

[1] G. Elliot Smith and W. R. Dawson, *op. cit.*, pp. 57–8.

[2] G. F. Rouelle, Sur les embaumemens des Égyptiens, *Histoire de l'Académie Royale des Sciences*, 1750 (Paris, 1754), p. 126. Rouelle states (p. 127) that the nitre of the ancients was not saltpetre, but *natrum*, ' *un vrai sel alkali fixe*,' that is to say natron.

[3] P. C. Rouyer, Notice sur les embaumemens des anciens Égyptiens, *Description de l'Égypte, Antiquités, Mémoires*, I (1809), p. 209. Rouyer says (p. 212) that *natrum* was obtained from several lakes in Egypt, where it occurred abundantly as ' *carbonate de soude*.'

[4] J. G. Wilkinson, *The Manners and Customs of the Ancient Egyptians*, II (1841), pp. 452–3.

[5] G. Rawlinson, *Herodotus* (1862), II: 86–8.

[6] A. D. Godley, *Herodotus* (1926), The Loeb Classical Library, II: 86–8.

for seventy days, embalmed in saltpetre,'[1] which strongly suggests that it was hidden in, or covered with, solid material; in the second and third methods 'they embalm the body.'

Turning now to the original Greek, the word used by Herodotus[2] to explain the operation of embalming in the three methods described is the same in each case, namely ταριχεύουσι, which is the third person plural, present indicative, active voice of the verb originally meaning to preserve fish with salt,[3] and hence the literal meaning is that they (the embalmers) preserved the body in a manner similar to that in which fish were treated. But, as the description is qualified in one place by the word λίτρῳ, meaning 'with natron,' to embalm, therefore, meant to preserve the body like fish, but using natron instead of salt. Both Herodotus[4] and Diodorus[5] employ other tenses and variants of the same verb and also related nouns in connexion with embalming. Variants of the verb are used, too, by Herodotus[6] with reference to preserved fish and preserved birds and by Diodorus[7] for preserved fish.

Athenaeus, a native of Naucratis in Egypt, who lived in Rome at the end of the second century A.D., and the beginning of the third century, discourses at great length on the subject of preserved fish, mentioning it more than sixty times in the space of a few pages and he always employs the same word, or one of its derivatives, that is used by Herodotus and Diodorus, not only for preserved fish, but also for mummies, and in one instance he calls attention to the use by Sophocles of the same word for mummy as for preserved fish.[8]

In a number of Egyptian papyri written in Greek, dating from about the first century A.D. to about the seventh century A.D.,[9] the

[1] The word λίτρον, usually νίτρον in later Greek writings (e.g. Strabo, *Geography*, XVII: 1, 23), means natron (natural soda) and not saltpetre, as translated by Godley.

[2] II: 86–8.

[3] For the meaning and use of the word see H. Stephano, *Thesaurus Graecae Linguae*, VII, 1843–47.

[4] II: 67, 69, 85–90; III: 10, 16; VI: 30. [5] I: 7; II: 1.

[6] II: 77; IX: 120. Godley's translation 'preserved with brine' is misleading, since brine means a salt solution, whereas salt is not mentioned, but only inferred, and there is no indication that a solution was used and a strong probability that dry salt was employed.

[7] I: 3. [8] *The Deipnosophists*, III: 116–21.

[9] B. P. Grenfell and A. S. Hunt, *The Oxyrhynchus Papyri*, I, p. 84; III, p. 256; IV, p. 228; VI, p. 293; X, p. 254; *The Amherst Papyri*, II, p. 150; B. P. Grenfell, A. S. Hunt and H. I. Bell, *op. cit.*, XVI, p. 202. B. P. Grenfell, A. S. Hunt and D. G. Hogarth, *Fayum Towns and their Papyri*, pp. 105, 107. The same rendering occurs also in the Zenon papyri and other papyri that need not be enumerated.

same word, or a variant of it, that is used by Herodotus and Diodorus to describe both the making of mummies and the preserving of fish, is employed sometimes in connexion with mummies and sometimes in connexion with fish, and in one instance, where the context does not help, it has not been possible for the translators to decide whether a certain word means fish curers or embalmers.

There is nothing in the original Greek of Herodotus' description of embalming to warrant the idea that a bath or solution was employed in which the body was soaked. The phraseology of Herodotus, Diodorus, Athenaeus and other writers makes it perfectly clear that the ancient Egyptian process of embalming the human body was analogous to that for preserving fish, and Herodotus amplifies this by stating that the preservative agent was natron. The modern method of preserving fish, apart from smoking and tinning in oil, which were not known anciently, is usually by salting and drying, though a few kinds are preserved in brine, that is in a salt solution. In Egypt at the present day fish are generally preserved by means of dry salt. Anciently in Egypt fish were preserved by drying, with, or without, the use of salt.

Since the aim of mummification was not merely to preserve the body, but to preserve it in a dry condition, it would have been both unnecessary and irrational to have begun by soaking it in a solution for a lengthy period, especially when the material employed, if used in a dry state, would have given better results than when used as a solution, and without the very objectionable putrefaction and intensely disagreeable smell attendant upon the wet method. Another reason for thinking that the process was a dry and not a wet one is that human bodies were undoubtedly mummified in a manner analogous to that in which fish were preserved (fish curing antedating mummification), but with natron instead of salt, and both ancient and modern methods of preserving fish generally apply salt in the dry state and not as a solution. Sometimes, however, fish, especially certain kinds of fish, are preserved in a solution (brine), but in these instances the fish remain in the brine until sold to the consumer, since, if removed, they quickly putrefy, and this mode of preserving fish, therefore, has no bearing on the method of embalming, as it was in the dry condition that the mummy was returned by the embalmers to the relatives and in the dry condition that it was buried.

Although the viscera were usually placed in the tomb in a dry state, in at least one instance they were preserved and left in a solution of natron, namely, in the case of Queen Hetepheres, but the body had

always to be dry, since it had to be bandaged, since amulets and jewellery had to be placed on it and since it was buried in a wooden or cartonnage coffin.

When the specimens of brain and resin impregnated with natron were examined and first described by me,[1] I thought that for the natron to have become so intimately incorporated with the material, it must have been used in the form of a solution, that is as a bath. I now realize, however, that there are other possible explanations; for instance, the body may have been washed with a natron solution, as was sometimes done,[2] or a little solid natron left on the body after treatment might have been dissolved by the water employed for the subsequent washing and so might have penetrated to the brain. The resin may have become contaminated by coming into contact with solid natron, either accidentally or intentionally, during the embalming process. In some such manner, too, the presence of natron on Granville's mummy, on the Leeds mummy, and on the mummy of Nekhtakh may reasonably be explained.

Turning now to the mummy itself to ascertain whether that ever shows evidence, such, for instance, as pathological changes, that would indicate the nature of the preservative agent used, the conclusions of Sir Armand Ruffer may be quoted, since, so far as is known to me, his are the only studies on the subject that have been made.

Ruffer at first accepted the current idea of a bath in which the body was soaked and, as the outcome of his earlier investigations, he stated[3] that 'It appears to me probable that the solution used was one of "natron", but that this "natron" consisted chiefly of sodium chloride with a small admixture of carbonate and sulphate of soda.' Later, however, as the result of further work, he evidently changed his opinion, since in an unfinished article published after his death he wrote as follows[4]:

'The histological study of the skin does not point to the regular use of a natron bath.' '... there is no evidence whatever for the supposition that the body was ever steeped in a natron solution.' 'The wound through which the organs were extracted is always clean, not encrusted

[1] A. Lucas, *Preservative Materials Used by the Ancient Egyptians in Embalming*, pp. 13–8.

[2] A. M. Blackman, *Rec. de travaux*, XXXIX, p. 53; *Ency. of Religion and Ethics*, X, p. 476.

[3] Sir M. A. Ruffer, Histological Studies on Egyptian Mummies, *Mém. Inst. Égyptien*, VI (1911), p. 31.

[4] Sir M. A. Ruffer, *Cairo Scientific Journal*, IX (1917), pp. 48–51.

with natron, and nothing in its state suggests exposure to the action of a caustic fluid.' 'Microscopical examination of the muscles of the abdominal wall does not suggest contact with natron. Even if, after immersion, the natron had been carefully washed out of the body—a very difficult and tedious operation—some chemical or histological evidence of use of the natron bath would have been expected. There is no such evidence.' 'The organs, which had first been removed from and then replaced in the body, also show no signs of having been steeped in natron, and it is very difficult to believe that any amount of washing could have removed the natron so thoroughly as to leave no trace of it behind.' 'Microscopically the parietal and visceral pleurae, the capsule of the liver, the kidneys and, above all, the intestines show no signs whatever of having been in contact with an alkaline fluid.' '. . . the contention of Schmidt, who asserts as a fact that the bath used was one of sodium chloride. The chemical evidence on which this theory is based is of the thinnest and the biological evidence is practically nil.' 'My objection to the theory of the natron or salt bath is that, unless a saturated solution of either was used, it would have led to the most intense putrefaction . . . If, on the other hand, a saturated solution was used, then, in spite of all successive washings, some excess of salt or natron should be present either on the muscles, skin or elsewhere. This, however, is not the case.'

'Although, therefore, I agree that salt and natron were used by embalmers I can find no evidence that the bodies were placed either in a natron bath or in a salt bath.'

The evidence from the pathological examination of mummies, therefore, furnishes no justification for thinking that the bodies were soaked in a bath or solution, but it all points in the opposite direction.

The various arguments advanced in favour of a bath are, first, that the epidermis of mummies is often missing; second, that the finger nails and toe nails are sometimes found tied on, manifestly to prevent them falling off during the mummification process; third, that the body-hair is frequently absent; fourth, that the packing of the limbs that was a special feature of mummification during the Twenty-first Dynasty could not have been carried out unless the skin and tissues had been softened by soaking, and, fifth, that bodies evidently sometimes came apart, since they are occasionally wrongly assembled, or left with some of the limbs missing, and this dismemberment can only be accounted for by lengthy maceration in a bath.

Elliot Smith attributes the loss of the epidermis to the action of the bath and says 'the skin shows unmistakable signs of having been macerated until the cuticle . . . has peeled off'[1]; 'the general epidermis, as it was shed (which occurred when the body was steeped . . . in the preservative brine bath)'[2]; Elliot Smith and Warren Dawson say[3] 'in the steeping process the epidermis peeled off'; 'the epidermis is nearly always absent owing to maceration.'

Winlock states[4] 'After the removal of the viscera the body must have been given a more or less prolonged soaking in a saline bath. This we assume from the facts that all the finger and toe nails have been tied with thread to prevent their loss during the maceration in such a bath, and the skin presented an appearance difficult to explain in any other way,' and again,[5] 'There was ample evidence for a bath in the mummies which dated from the XXI to the XXV Dynasties unwrapped by me. Packing of the legs and arms could only have been accomplished when the bodies were extraordinarily soft and pliable. The almost total disappearance of muscles and other soft tissues in the limbs can only be explained by prolonged maceration—not by drying. The soft, pulpy, and easily torn and abraded skin during manipulation would never have appeared on a dried body. It would never have been necessary to tie the finger and toe nails on with thread during drying but it would have been necessary during soaking. Epidermis fallen from dried bodies is paper thin—soles of feet from characteristic XXI–XXVI Dynasty mummies are fairly thick as though they had been pickled. On the other hand XI Dynasty, Roman and Coptic mummies unwrapped by me appeared often to have been merely dried —either before or after burial—and showed none of the signs of soaking.'

Warren Dawson states[6] 'During this long immersion the epidermis peeled off, taking with it the body-hair, and it was for this reason also that special care was taken to secure the nails so that they should not come away with the macerated skin and be lost. To accomplish this end, the embalmers cut the skin round the base of the nail of each finger and toe, so as to form a natural thimble. Around each such

[1] G. Elliot Smith, *Mém. de l'Inst. Égyptien*, v (1906), 1, p. 18.
[2] G. Elliot Smith, *The Migration of Early Culture* (1929), p. 23.
[3] G. Elliot Smith and Warren R. Dawson, *Egyptian Mummies*, pp. 88, 124.
[4] Private letter.
[5] H. E. Winlock, *The Tomb of Queen Meryet-Amun at Thebes*, p. 10.
[6] W. R. Dawson, (*a*) Making a Mummy, *Journal of Egyptian Archaeology*, XIII (1927), p. 43; (*b*) *Magician and Leech*, pp. 39–40.

thimble they wound a thread or a twist of wire to hold the nail in place. In the case of kings and wealthy persons, the thimbles of skin with their nails were kept in position by means of metal stalls. The mummy of Tut-ankhamun had a set of gold stalls in position. It is specially to be noted that the head was not immersed, for it always retains the epidermis and the hair (unless the scalp had previously been shaved) and does not present the same appearance of emaciation as the rest of the body.'

Warren Dawson also writes[1] 'I have examined a great number of mummies, and, with the exception of two cases, the epidermis was always entirely absent from the whole body, except from the head, fingers and toes where its cut edges are visible. I agree that simple maceration might not be sufficient to detach the whole of the cuticle, but it would certainly loosen it and make it easy to remove by scraping, a practice followed in other parts of the world. I have also both seen and read of packets of detached epidermis wrapped in linen and buried with the mummy. With the exception of the two cases afore-mentioned, I have never found a trace of pubic, axillary or other body-hair, nor even stumps that might indicate cutting or shaving. It always comes away with the epidermis.'

Professor Battiscombe Gunn writes[2]: 'One point, however, strikes me in this connection. The well-attested fact that mummies when unwrapped are often found either to have a limb or limbs missing, and replaced with sticks, etc., or else to be made up with other people's limbs, having three arms and one leg or vice versa—this fact is usually explained by the body having come apart in the pickling bath. If the bodies were merely dehydrated with dry natron, it is not easy to explain the loss of limbs. Have you any alternative explanation? I think that with many people such cases will constitute a strong objection to your theory.'

The various arguments quoted that have been put forward in favour of a soaking of the body will now be considered.

That the epidermis, except that on the head, fingers and toes, is often missing; that packets of shed epidermis occasionally have been found with mummies,[3] and that the body hair generally is absent are not disputed. The suggestion that this condition was caused by

[1] Private letter, 1933.
[2] Private letter, 1933.
[3] G. Elliot Smith and F. Wood Jones, Arch. Survey of Nubia, Report for 1907–1908, *Report on the Human Remains*, pp. 200–1.

prolonged soaking in a bath has been dealt with by Ruffer, who, therefore, may be quoted. He says of the mummy of a woman that 'the *rete mucosum* of the skin of chest and mammae is almost completely gone,'[1] but he explains that at first he 'attributed this state of things to the effect of the salt bath, but that it cannot be wholly due to this is proved by the fact that the epidermis of bodies which had certainly never been placed in the bath had also fallen off.'[1] He states, too, that 'in many cases the epidermis, especially that of the toes and hands, is practically normal'[1]; 'it has been taken for granted that the natron bath . . . would so soften the skin that the epidermis would either fall off in the bath or be easily stripped off afterwards, and because the epidermis has evidently been removed in some instances, this was assumed to have been the result of the natron bath'[2]; 'very often . . . the epidermic layer is absent, but in mummies of the twenty-first Dynasty . . . the epidermic layer can often be demonstrated'[2]; 'the skin of mummies of the Roman epoch is as a rule perfect, the epidermis shows no signs of having been shed'[2]; 'it has been taken for granted that a solution of natron . . . would loosen the cuticle so much that this could easily be removed. As a matter of fact the evidence . . . is nil'[2]; 'the fact that the skin, including the epidermis, of certain bodies was almost normal shows that the " natron " bath cannot always have had a very powerful macerating effect.'[1] Ruffer further explains that 'with the onset of putrefaction the epidermis is raised and ultimately falls off'[1]; and quotes the instance of a body of a child where 'there was absolutely no sign that it had been touched by the embalmer,'[1] and yet 'the whole of the epidermis of the soles of the feet and toes was almost completely detached.'[1] The fact that the epidermis of mummies is often absent, therefore, is not proof that the body had been soaked in a solution, since putrefaction alone may have been the responsible agent.

Further, that the epidermis may, at first sight, appear to be absent is no proof that it really is absent, since Elliot Smith says[3] of a particular mummy 'Unlike all other mummies examined by me (excepting only those of the Coptic period) the epidermis was not removed during the process of embalming. It is present, peeled off, it is true, but adhering to the bandages, wherever they came in contact with the body.' May it not be, therefore, that in other instances, for

[1] Sir M. A. Ruffer, *Studies in the Palaeopathology of Egypt*, pp. 66, 67, 69, 70.
[2] Sir M. A. Ruffer, *Cairo Scientific Journal*, IX (1917), pp. 47, 48.
[3] G. Elliot Smith, *The Royal Mummies*, p. 9.

example where the bandages were in poor condition (the bandages next to the body are often blackened and friable and may even be in the condition of black powder) that the epidermis was present adhering to the bandages, but was not recognized?

With respect to the finger and toe nails sometimes being tied on, may it not be that the drying and consequent shrinkage and emaciation, or incipient putrefaction, or both, would have so loosened the nails that these would have been in danger of falling off unless tied? The use of finger and toe stalls certainly was not to prevent the nails falling off, since the stalls were not put on until after the mummification was finished and after the fingers and toes had each been wrapped separately in linen, as is shown in the case of the mummy of Tut-ankhamun. Thus Howard Carter states[1] 'Each finger and thumb having been primarily wrapped in fine strips of linen, was enclosed in a gold sheath.' The toes also had been treated in a similar manner and wrapped separately before the stalls were put on.

As for the body-hair being missing, this naturally would fall off with the epidermis, which Ruffer states was due to putrefaction and not to soaking. The caustic natron might also have a corrosive effect on the hair, which is easily destroyed by alkalies.

The packing of the legs and arms, as was done in the Twenty-first Dynasty, Winlock says[2] 'could only have been accomplished when the bodies were extraordinarily soft and pliable' and that the 'almost total disappearance of the muscles and other soft tissues in the limbs can only be explained by prolonged maceration—not by drying,' but I do not agree, and the reasons will be given in due course. With respect to the action of a solution, Elliot Smith states[3] 'While the body is in the saline solution the skin and the lining of the body cavity become toughened by the action of the salt; but the soft tissues under the skin in the limbs, back and neck are not exposed to the action of the preservative agent and soon become reduced to a soft pulpy mass, which is of a fluid or semifluid consistency. It was the practice of the embalmers in the time of the 21st. dynasty to stuff into this pulpy mass large quantities of foreign materials so as to restore to the collapsed and shrunken members some semblance of the form and consistency they possessed during life.' But that any preservative or desiccating agent should pass through the skin and lining membranes of the body

[1] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, pp. 129–30.
[2] H. E. Winlock, *The Tomb of Meryet-Amun at Thebes*, p. 10.
[3] G. Elliot Smith, *Mém. de l'Inst. Égyptien*, V (1906), p. 19.

cavities, toughening them in the process, but softening and disintegrating the tissues underneath, seems most unlikely. There is also a contradiction in the statement itself, since 'a soft pulpy mass' is not quite the same as being of 'a fluid or semifluid consistency.'

Elliot Smith also writes[1] that 'The examination of mummies of the New empire reveals the fact that during the process of mummification . . . the soft tissues of the body (excepting the skin which was exposed to the action of the preservative agent) became converted into a loose spongy material which was much too soft and too small in amount to keep the skin distended: as a result the limbs became reduced to little else than bones with an ill-fitting wrapping of deeply wrinkled skin . . . In the 21st. dynasty the embalmers endeavoured to remedy this effect by stuffing various materials . . . under the skin so as to distend it and mould it to the form of the body.' A 'loose spongy material,' as now mentioned, is not the same as a 'soft pulpy mass' previously described, much less is it 'of a fluid or semifluid consistency.' These criticisms may at first sight appear trivial and unnecessary, but they are neither, since an important principle is involved, for if the tissues were reduced either to a soft pulpy mass, or to a fluid, or semifluid consistency, for which no evidence is given, this might prove that the bodies had been soaked in a solution for a lengthy period, whereas in my opinion a bath was never employed. In certain experiments I made with chickens and pigeons, I found that both the skin and the tissues became softened as the result of soaking, and that immediately after removal from the solution, although not reduced to a fluid or semifluid consistency, they were 'soft and pulpy to the touch,'[2] and the skin had become so soft that 'it was difficult to handle the bodies without rubbing off portions of the skin.'[2] In such a condition I believe that it would not have been possible to have packed any material under the skin, as was done by the embalmers of the Twenty-first Dynasty, without rupturing it considerably and partly destroying it; also, there would not have been any room for packing material, and it was only after the flesh had dried and shrunk that packing became either necessary or possible. The packing, therefore, instead of being evidence of soaking, is, in my opinion, proof of the contrary.

[1] G. Elliot Smith, *Mém. de l'Inst. Égyptien*, v (1906), p. 10.

[2] A. Lucas, (*a*) *Preservative Materials Used by the Ancient Egyptians in Embalming*, 1911, pp. 9–10; (*b*) The Use of Natron in Mummification, *Journal of Egyptian Archaeology*, xviii (1932), pp. 133–4.

Ruffer states[1] that 'there is no proof that the tissues were changed into a soft pulpy mass, I have examined several mummies, the limbs of which had not been packed by the embalmers and I found the muscles, nerves and arteries etc. in a very good state of preservation.'

According to the experiments I made with pigeons and dry natron,[2] the body became much emaciated and the skin loose and wrinkled, in which condition it would have been an easy matter to have packed it in the manner that was customary during the Twenty-first Dynasty. Elliot Smith states[3] of a certain mummy that 'The skin is . . . soft, moist and tough' and again 'the skin has become softened and flexible.' Elliot Smith and Warren Dawson state[4] that the skin of many of the bodies of early Christian date that had not been soaked, but on which salt was found, was 'entire, soft and pliable.' Soaking, therefore, was not necessary in order to make the skin soft and pliable. Also, it may be mentioned that the epidermis from the soles of the feet of the woman found in the coffin lid bearing the name of Set-Nekht,[5] which was examined by me, was very soft and pliable, and is still in the same condition, more than thirty years after its first examination, and it could be stretched and packed, and this skin certainly was preserved with solid natron, which was found with it. Also, if in any instance the skin were too dry and brittle to allow of packing, might not the anointing with oil or fat that followed the desiccation and was part of the mummification process have restored its pliability?

The facts mentioned by Gunn about the redundant limbs are well known. Jomard in 1809[6] refers to ancient false mummies and examples have been found in Nubia[7] and elsewhere. These defective and composite mummies are of two main classes, namely (*a*) those like the royal mummies found at Deir el Bahari and in the tomb of Amenophis II respectively, which had been maltreated by robbers in search of plunder and subsequently restored and re-wrapped and then hidden to protect

[1] Sir M. A. Ruffer, *Mém. Inst. Égyptien*, VI (1911), p. 131.

[2] A. Lucas, The Use of Natron in Mummification, *Journal of Egyptian Archaeology*, XVIII (1932), pp. 133–4.

[3] G. Elliot Smith, *The Royal Mummies*, pp. 9–10.

[4] G. Elliot Smith and Warren R. Dawson, *Egyptian Mummies*, p. 131.

[5] (*a*) G. Elliot Smith and Warren R. Dawson, *op. cit.*, p. 101; (*b*) A. Lucas, *Preservative Materials Used by the Ancient Egyptians in Embalming*, pp. 6–7.

[6] E. Jomard, Description des hypogées de la ville de Thèbes, *Description d'Égypte*, 1809, I, pp. 345–6.

[7] G. Elliot Smith and F. Wood Jones, Arch. Survey of Nubia, Report for 1907–1908, *The Human Remains*, pp. 213–5.

them from further damage, the condition of which has no connexion with the manner of embalming, and (*b*) mummies not damaged by robbers and then re-wrapped. Some of these latter are deliberate frauds made in modern times and often put into genuine old coffins in order to sell to tourists. Jomard says[1] that not only were there ancient false mummies, but that in his day the Arabs and the Jews made modern ones, and Pettigrew in 1834 states[2] that Mr. Madden saw ' a manufacture of mummies ' at Qurna, opposite Luxor (where false mummies are still made), these being put into old coffins. Other defective mummies may be incomplete because the body had been allowed to undergo considerable decomposition before it was embalmed, as, for instance, according to Herodotus,[3] was customary in the case of women of the better class. With reference to this, Elliot Smith and Warren Dawson state[4] that ' It may be observed that there is abundant evidence that some of the bodies were in an advanced stage of decomposition when treated by the embalmers, and this condition in nearly every case applied to women. Derry says[5] ' Some of these jumbled collections of bones are undoubtedly examples of bodies which have been disturbed either by robbers or otherwise, and subsequently re-wrapped by some person who discovered the remains and, while collecting them, included bones found in the vicinity from a neighbouring tomb.'

But, allowing for both of these categories mentioned, there still remain a large number of mummies the state of which requires accounting for. The usual explanation, either given or implied, is that their condition is due to the bodies having been soaked in an embalming solution in such a manner, or for such a period, that they became dismembered and that insufficient care was taken to keep the several parts of one body separate from those of others, in consequence of which mistakes were made in assembling the parts, whereby some bodies were left with limbs missing, or the limbs allotted to them did not belong. But no evidence is offered to show that soaking in a natron solution, even if prolonged, would cause the limbs to separate from the body, but that this might happen with certain strengths of natron is not denied, though it did not happen in some experiments made by me

[1] E. Jomard, *loc. cit.*
[2] T. J. Pettigrew, *A History of Egyptian Mummies*, p. 228.
[3] II: 89.
[4] G. Elliot Smith and Warren R. Dawson, *op. cit.*, p. 125.
[5] D. E. Derry, Mummification, *Annales du Service*, XLI (1942), p. 265.

with chickens and pigeons that were soaked in natron solutions,[1] but it did occur in one instance when a solution of common salt was used in place of natron.[1] But, even though it be accepted that the use of a natron bath could cause dismemberment of the bodies, for which, however, there is no proof, this would solve only part of the problem. The defective and composite mummies that are not cases of re-wrapping are practically, if not entirely, limited to very late periods, Persian, Ptolemaic and Roman, and apparently most, if not all, are of persons of the poorer classes and, therefore, any explanation, before it can be accepted, must show the reason for this limitation in both time and status, which the bath theory does not.

The condition of these late mummies is probably correlated to the fact that about the beginning of the period to which they belong 'less and less attention was paid to the body and more and more to the external wrappings'[2] and 'the processes were getting slipshod and the practitioners careless, when much of the care which in earlier times was devoted to the body itself was now being given mainly to the outward appearance of the wrapped mummy'[3] and so long as this 'displayed a presentable exterior it seemed to matter little to the embalmer how careless and slipshod was the work upon the corpse concealed beneath the carefully wrought external coverings.'[2]

No wholly satisfactory solution of the difficulty can be suggested, but two facts are certain, namely, first, that the bodies must have been desiccated in some manner before they were wrapped up (which as shown elsewhere[1] was best attained by the use of dry natron), and second, that more than one body was dealt with at the same time and place, hence some 'wholesale' treatment seems indicated. Whatever it was there must have been some deviation from the old practice, since it is only at the late periods that the defective and composite mummies are found. Some method resulting in a considerable decomposition of the body seems certain, possibly a method dictated by the need of economy (since more expense was being incurred for the wrapping). One obvious economy would have been to reduce the amount of natron used (that the great purifying agent should have been entirely omitted is unlikely) and another might have taken the form of the repeated use and re-use of the same natron until it had little or no preservative property left.

[1] A. Lucas, *Journal of Egyptian Archaeology*, XVIII (1932), pp. 133–4.
[2] G. Elliot Smith and Warren R. Dawson, *op. cit.*, p. 121.
[3] G. Elliot Smith and F. Wood Jones, *op. cit.*, pp. 213–5.

One very strong argument against the use of a bath for soaking bodies on a wholesale scale is that even for two bodies a very large receptacle would have been required, and for a large number of bodies the receptacle would have been enormous. On the other hand, to place a number of bodies on the ground, or on mats, and to cover them with dry natron would have been an easy matter, and, if the bodies were those of poor people, who were paying the minimum price, it might well have happened that sometimes there was inadequate protection against pariah dogs, or even against jackals, and that occasionally bodies might have been disturbed by these animals, or even parts of a body might have been carried away.

As further evidence against the employment of a solution for embalming we have the fact that no vessel of the size or kind that must have been used for the bath, had there been a bath, has been found. Whether the body had been stretched at full length in the horizontal position in an oblong receptacle, or placed, as suggested by Dawson,[1] in a sharply flexed position in a large jar, the vessel would have been either pottery or stone; but no such vessel, either whole or broken, has ever been discovered, nor even any pieces of material suggesting such a vessel. Pottery jars of sufficiently large size to contain a human body are known, but they are often of a date anterior to mummification and they have never been found in such circumstances or in such a condition as to suggest their use in embalming. The pottery vessels employed by me for soaking the chickens and pigeons used in my mummification experiments were so impregnated with natron and salt respectively that there was no mistaking the nature of the solutions they had contained, and the condition of any pottery vessel used in mummifying the human body by soaking would have been equally unmistakable.

Although a pottery or stone vessel might have been used for the dry method of embalming, this would not have been essential, and a wooden box[2] would have been equally suitable; or the packing in natron might have been done on an embalming platform, such as that found by Winlock, or on a mat, such as was also found by Winlock, or even on the ground. The actual method of applying the natron is not known, but the repeated occurrence of a large number of small parcels of this material tied up in linen cloth found with refuse embalming

[1] W. R. Dawson, *Journal of Egyptian Archaeology*, XIII (1927), p. 44.

[2] The wooden coffins that have been found containing refuse embalming material may have been used for this purpose.

material might be explained by supposing that each parcel was a unit of some kind, and that possibly a number of them were packed into the body cavities (thorax and abdomen)[1] or placed on the body or only in special positions on the body, as for instance on the face, the rest of the body being covered with the loose powdered material. In one case a small packet of white powder, probably natron, was found stuffed in the mouth of a mummy of Twenty-fifth Dynasty date.[2] One frequent feature, too, of natron found with refuse embalming material is its admixture with sawdust, which may have been added as an additional absorbent.

In order to determine the action of salt and natron respectively I, then accepting the prevalent idea that the preservative material was employed in the form of a solution, soaked two chickens (plucked and eviscerated) for seventy days in an eight per cent solution of natron and one chicken for the same length of time in an eight per cent solution of common salt. There was much putrefaction with considerable smell in both cases. After the soaking, the chickens were immersed in water for about a minute and then exposed to the air for a fortnight to dry. As soon as the fowls were removed from the bath they were examined and it was found that all three, although plump, were soft and pulpy to the touch. It was very difficult to handle them without rubbing off portions of the skin, and of the two which had been in the natron, one was very much discoloured, with the bones of the lower part of one wing bare; the other also was discoloured in places, and some of the skin had disappeared, but there were no bare bones. The fowl which had been in the salt solution, however, was in a much worse condition than either of the other two; part of the neck, the ribs on one side of the body, the backbone, practically the whole of one wing and the lower part of one leg were entirely free from either flesh or skin, the bones being quite bare, and from the rest of the body the skin was in parts loose and hanging in strips. After the fowls had been exposed to the air for a fortnight they were again examined. They were all hard, dry and very much shrunken. Of the two which had been in the natron, one was practically all skin and bone, very much discoloured, with the bones of the lower part of one wing bare; the other retained a good deal of the flesh, which was pink; it was

[1] The value of this would have been the ease with which they could have been withdrawn when the operation was finished.

[2] G. A. Wainwright, *Heliopolis, Kafr Ammar and Shurafa*, W. M. F. Petrie, E. Mackay and Others, p 35.

discoloured in places, and some of the skin had disappeared, but there were no bare bones. In the case of the fowl which had been in the salt solution, as already mentioned, practically the whole of one side consisted of bare bones, but the other side was white, dry and hard, and seemed to be nothing but skin and bones, and the skin which previously had been loose had adhered again.[1]

Under the conditions of the experiments and with the particular strength of solutions employed, all three chickens were preserved, but the two that had been in the natron solution were in a much better condition than the one that had been in the salt solution. These mummified chickens were kept for thirteen years before being destroyed, at the end of which time they were in as good a state of preservation as when they were first prepared. Unfortunately no determinations were made to ascertain whether or not the skin and flesh of the chickens had become impregnated with natron and salt respectively, and in order to remedy this omission, further experiments were carried out,[2] using pigeons in place of chickens and a three per cent solution of natron[3] and salt respectively instead of an eight per cent solution, three per cent being the strength of the natron solution found in the canopic box of Queen Hetepheres.

Moreover, in order to determine the effects of dry natron and salt, experiments with both these materials were also made as follows: a thick layer of natron[3] in one case and of salt in the other was put at the bottom of a glazed earthenware vessel, and on this in each vessel a pigeon (plucked and eviscerated) was placed, which was then thickly and completely covered with natron or salt, the body being concealed as described by Herodotus. The duration of all four experiments was reduced from seventy days, which was the period previously chosen, to forty days, the latter being probably more nearly the time taken anciently for this part of the embalming process.[4]

At the end of forty days the experiments were discontinued and the pigeons were taken out of the natron and salt and examined. The pigeon that had been in the natron solution was bleached white, but was whole, plump and in good condition with the skin intact. It was rinsed under the tap, immersed in water for fifteen minutes, drained

[1] A. Lucas, *Preservative Materials Used by the Ancient Egyptians in Embalming*, pp. 9–10.

[2] A. Lucas, *Journal of Egyptian Archaeology*, XVIII (1932), pp. 125–40.

[3] Containing 29.4 per cent of sodium chloride (common salt) and 9.8 per cent of sodium sulphate.

[4] F. Ll. Griffith, *Stories of the High Priests of Memphis* (1900), pp. 29–30.

and dried. While it was draining, putrescent blood-coloured fluid came away for several hours, and a slight smell of putrefaction remained for some weeks. The pigeon from the salt solution was no longer recognizable as such, having been reduced to a formless mass of skin, bones and fat (no flesh). The remains, which were bleached white, were rinsed, washed, drained and dried like the other pigeon. During the forty days the pigeons were soaking there was a very strong smell of putrefaction from both.

The pigeons that had been buried in solid natron and salt respectively were much alike, being hard, dry and much emaciated, with the skin intact; they were practically free from disagreeable smell, of which there had been very little during the forty days of burial. Neither pigeon was bleached. The natron from the one, where it had been in contact with the body, was discoloured and consolidated from the effects of the exuded body fluids and contained a large number of small dead insects (probably larvae). On dissolving this natron in water, the solution was much discoloured and a considerable number of additional insects became manifest. There were also a number of these insects adhering to the body. The salt from the other pigeon had become slightly consolidated from the exuded body fluids, but was not visibly discoloured, though on dissolving it in water a discoloured solution was produced, in which were a few dead insects similar to those from the first pigeon, but there were no insects on the body. After nine days' drying the pigeons were examined for the presence of natron and salt. There was no visible efflorescence or other perceptible indication of either, but on testing, salt was found in all four instances, in two of which it had manifestly been derived from that contained in the natron. There was no natron present on the two pigeons that had been treated with this material, the bodies being very slightly acid, as were also the two pigeons that had been treated with salt, though with these latter the acidity appeared to be slightly greater.

Birds (chickens and pigeons), therefore, may be preserved whole and in good condition by soaking them either in an eight per cent solution of natron for seventy days, or in a three per cent solution of natron for forty days. Birds may be preserved, too, though not nearly in such good condition by soaking them for seventy days in an eight per cent solution of common salt, but they are not preserved when the strength of the solution is reduced to three per cent. Birds are dried and excellently preserved by packing them for forty days either in dry natron, or dry salt. Birds that have been treated with natron do not contain

natron, but are acid, the alkali of the natron having been more than neutralized by acid decomposition products of the body. These birds, too, contain salt, derived from that originally present as an impurity in the natron. Birds that have been treated with salt contain salt and also are acid from the acid decomposition products of the body.

The experiments prove very definitely the falsity of the argument often used against the employment of natron for desiccation, namely that mummies are generally acid and not alkaline, and that, therefore, an alkali cannot have been used. A body, however, may have been treated with natron and still be acid, as is proved by the two pigeons mummified by me, one of which had been immersed in a natron solution for forty days and the other buried in solid natron for the same period. The reason for this apparent anomaly is manifestly that in most cases the fatty acids and possibly other acid products of decomposition have more than neutralized the small amount of alkali (natron) left on the body after washing. The probability that this would prove to be the case was suggested by me many years ago.[1]

There cannot be any doubt whatever that the essential operation in all methods of mummification in ancient Egypt was the desiccation of the body, and although certain details of the mummification process varied from time to time, the deliberate drying of the body remained the principal feature and this, I believe, was brought about by the use of dry natron, and not by soaking in a solution.

The Eleventh Dynasty royal bodies found by Winlock in the Mentuhotep cemetery at Thebes[2] and examined by Derry would seem to have been an important exception. These bodies had not been eviscerated and Derry states[3] ' Complete desiccation of the bodies before bandaging is ruled out because the skin is folded and bears impressions of jewellery which shows that the bodies were still soft and pliable at the time of bandaging and the mould-like form of the bandages shows that the emaciation took place after wrapping,' and ' liquids from decomposition had penetrated the bandages even to the outside ' and had made of them ' a more or less rigid mould of the body . . . which held its shape after the body has shrunk to far smaller proportions.'

[1] A. Lucas, *Preservative Materials Used by the Ancient Egyptians in Embalming*, 1911, p. 11.

[2] H. E. Winlock, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1920–1921*, pp. 37–52.

[3] From private notes kindly lent me by Dr. Derry. See also D. E. Derry, Mummification Methods Practised at Different Periods. *Annales du Service*, XLI (1942), pp. 246–57.

In these instances manifestly either the body had been treated only for a short time with the desiccating agent (natron) and then wrapped up, or the body had been wrapped up without any preliminary desiccation. From the condition of both the body and the wrappings the second suggestion seems the more probable, although it would have meant omitting, not only the drying properties of the usual natron, but also its supposed purifying virtues. Special purification ceremonies, however, to compensate for the absence of natron may have been used, or the washing of the body may have been done with a natron solution. The desiccation in these instances evidently took place wholly, or largely, in the tomb, but in the wrapped body it must have been a very slow process, despite the tomb temperature, which may have been as high as about 29° C. (84° F.).[1]

Other instances in which the body was not eviscerated are known. Thus Hayes says[2] of five Eighteenth Dynasty burials found by him in the Theban necropolis 'Although the viscera, brains, etc. were not removed from the bodies and packing inserted in their place, as in later periods of Egyptian history, the bodies themselves had been "cured" by a long process involving the use of natron and other salts and subsequently saturated with pitchy[3] preservatives, so that even after some 3,400 years under the most adverse conditions much of the tissue, skin, and hair is still intact.'

Pettigrew noticed a similar fact and says[4] 'Mummies very richly furnished and prepared in the most costly manner have been found without the ventral incision.'

Following the desiccation came the washing of the body, which must have been necessary after the evisceration and natron treatment, but beyond the material cleansing, there was need also for a ceremonial purification, which was carried out by means of a solution of natron. Blackman states[5] 'Natron . . . was often dissolved in the water to enhance its cleansing properties'; 'In the . . . embalmer's workshop the

[1] A. Lucas, Note on the Temperature and Humidity of Several Tombs in the Valley of the Tombs of the Kings at Thebes, *Annales du Service*, XXIV (1924), pp. 12–4.

[2] W. C. Hayes, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1934–1935*, p. 20.

[3] Not of course pitch, but resin that had blackened and become pitchlike in appearance.

[4] T. J. Pettigrew, *History of Egyptian Mummies*, p. 60

[5] A. M. Blackman, (*a*) *Hastings' Ency. of Religion and Ethics*, X, pp. 476, 479, 480; (*b*) *Recueil de trav.*, 39 (1921), p. 53; (*c*) *Journal of Egyptian Archaeology*, V (1918), pp. 117–24, 148–65.

corpse was washed with water in which various kinds of natron had been dissolved'; 'the water might contain natron,' and, describing a certain scene in a tomb chapel of Twelfth Dynasty date at El Bersha he says[1] 'The dead Dhuthotpe, fully clothed, stands upon an ablution pedestal between two lustrators, behind either of whom is a man with a vessel containing natron—natron being dissolved in the water to enhance its purification properties.'

The washing of the body is mentioned both by Herodotus[2] and by Diodorus.[3]

After the washing, an anointing with oil followed, which is referred to by Diodorus,[3] and as evidence of it may be mentioned the mats (one of a late period, Twenty-sixth to Thirtieth Dynasty, and the others of which the dates are not given) stained with oil found by Winlock in the Theban necropolis,[4] and the linen stained with oil found by Lansing in an embalmer's pit of Twenty-sixth Dynasty date, also at Thebes, part of which is in the Cairo Museum, where I have examined it. Some of this linen (originally five lots, of which the Museum took one) was wrapped into the shape of small mummies, the one I examined[5] being 33 cm. (13 inches) long, and containing a mixture of resin and sand, the linen being greasy in parts; other lots (originally twenty-nine, of which the Museum took nine,[6] called swabs in the Museum register, but probably embalmer's pads) were in various curious shapes. The linen was greasy and some of it was saturated with oil. With this linen there were two red pottery jars (one of which[7] I examined) with an embalmer's inscription on the neck, containing a compact mass of small bundles wrapped in greasy linen, all of which contained a mixture of resin and sand. Lansing and Hayes found 'oil-stained bandages' of Eighteenth Dynasty date, also at Deir el Bahari.[8]

No generalization can be made respecting the treatment of the body after lustration and before wrapping, since the procedure varied at

[1] A. M. Blackman, (*a*) *Hastings' Ency. of Religion and Ethics*, x, pp. 476, 479, 480; (*b*) *Recueil de trav.*, 39 (1921), p. 53; (*c*) *Journal of Egyptian Archaeology*, v (1918), pp. 117–24, 148–65.

[2] II: 86. [3] I: 7.

[4] H. E. Winlock, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1927–1928*, pp. 25–6.

[5] No. J. 65385 B.

[6] No. J. 65385 A.

[7] No. J. 65385 C.

[8] A. Lansing and W. C. Hayes, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1935–1936*, p. 23.

different periods, at different places and with the social status of the dead person.

After about the beginning of the Eighteenth Dynasty the brain was generally removed from the cranium, which sometimes was left empty and sometimes was filled with resin, or resin and linen, though occasionally during the Ptolemaic period it was filled with wood pitch (not bitumen).

The thorax and abdomen, from which the organs, except the heart, were removed, sometimes were left empty; sometimes they were filled with a solid mass of resin, or more generally with linen soaked in resin (the resin manifestly having been employed in the molten state and the linen probably having been used to economise resin), sawdust, or other materials; while at a late period the dried viscera were wrapped up and returned to the body. Sometimes the whole body was covered with resin, and in the case of the earliest known mummy, which, until 1941 when it was destroyed by a bomb, was in the Museum of the Royal College of Surgeons, London, the whole body was encased in resin-soaked linen, which was carefully moulded into shape, and the body cavities were packed with linen and resin. With respect to the mummy of Queen Meryet-Amun (Eighteenth Dynasty) Winlock states[1] that 'The body cavity was packed tightly with rags impregnated with resin and pure liquid resin was poured over the incision in the left flank until it formed a pool from 1 to 1.5 cm. deep.' 'The face was smeared with a black resinous paste.' 'After a few layers of cloth had been applied, the whole body was drenched in liquid resin.' 'Further wrappings and further drenchings were repeated.' With respect to one mummy he examined Derry writes[2] 'Two large fragments representing parts of the right and left sides of the thorax with the ribs in situ are filled with a mass which . . . proved to consist of linen combined with the same resinous material. This had evidently been introduced while hot . . .' In one instance of Eleventh Dynasty date the body was covered with beeswax.[3]

In many instances, especially with the later mummies, but also in the case of Tut-ankhamun, the whole body is very black and in some cases, and again in that of Tut-ankhamun, even the bones are black

[1] H. E. Winlock, *The Tomb of Meryet-Amun at Thebes*, pp. 10–1.

[2] D. E. Derry, The 'Mummy' of Sit-Amun, *Annales du Service*, XXXIX (1939), pp. 411–6.

[3] Mummy No. 23 found by Winlock in the Mentuhotep cemetery at Thebes. From private notes kindly lent me by Dr. Derry. See also D. E. Derry, *Annales du Service*, XLI (1942), pp. 246–57.

throughout, a condition that often is attributed to the body having been soaked in bitumen, for which there is neither evidence nor probability, and, in my opinion, as a result of having examined many of these mummies, including that of Tut-ankhamun, the blackening has been caused by a form of slow spontaneous combustion of the organic matter of that portion of the flesh remaining after the desiccation, and of the organic matter of the bones, whereby free carbon and carbonaceous matter have been formed. It may be mentioned that there is so much organic matter (about thirty per cent) in fresh dry bones that when the mineral matter is dissolved out with acid the bones retain their shape and resemble in appearance a gelatine cast of the original. Why particular mummies, and those chiefly of late date, should exhibit this blackening is not known, but it seems possible that it commenced with a fungus growth (mould) caused by damp, which at a later stage became a chemical process. If so, then lack of complete drying after washing and before bandaging may have been the predisposing cause. When a body coated with resin is black, such blackening may be very different and may be due to the burning and consequent blackening of the resin while it was being heated in order to melt it for ease of application, though there is some slight evidence that certain resins may become black with age, especially when in contact with fatty matter.

As already stated, for a long period after the introduction of embalming, it was confined to the kings and wealthier classes, but eventually simpler and cheaper methods were introduced, so that even the poor were able to avail themselves of some preservative treatment, chiefly desiccation by means of natron, and so they, too, might hope to attain to everlasting life.

So far, the only references made to any ancient description of the methods of mummification have been a few to Herodotus and Diodorus, who are the only ancient writers who have left accounts of the process, and, so far as is known, the ancient Egyptian records do not contain any details of the methods of embalming,[1] though in a document dated to the First or Second Intermediate period 'the secret art of the embalmers' is referred to.[2] The earliest detailed description is that of Herodotus,[3] who travelled in Egypt about the

[1] The so-called 'Ritual of Embalming' is the ritual of anointing and wrapping after embalming.

[2] A. H. Gardiner, *The Admonitions of an Egyptian Sage*, p. 37.

[3] II: 86–8.

middle of the fifth century B.C. (some time before 460 B.C.), the next earliest being that of Diodorus,[1] who visited the country about 400 years later, during the first century B.C., each of whom wrote an account of what he had seen and heard, including a description of the process of mummification. From the Twenty-sixth Dynasty (663 B.C. to 525 B.C.), however, which is earlier than Herodotus, there is the Apis Papyrus,[2] which contains a description of the embalming of the sacred bull Apis.

According to Herodotus, three different methods of embalming were practised. In the first, which was the most expensive, the brain was removed, partly mechanically and partly by means of certain drugs (the nature of which is not given); the abdominal contents were removed (probably this was meant to include the thoracic contents also, except the heart, though this is not specifically stated) and the removed viscera were cleaned with palm wine and spices, the cavity being filled with myrrh, cassia and other aromatic substances (the kinds of which are not specified), frankincense, however, being excluded, and the body, after the embalming incision had been sewn up, was then treated with natron, after which it was washed and wrapped in linen bandages, which were fastened together with gum. In the second method, 'cedar oil' was injected into the body *per anum*, and the body was then treated with natron. The third method, which being the cheapest was adopted by the poorer classes, consisted in cleaning out the intestines by means of an injection *per anum*, and afterwards treating the body with natron.

The account given by Diodorus, though possibly based on that of Herodotus, supplies several particulars not given by him, though it is not so detailed. Although three grades of funerals are mentioned, only one method of embalming is given, namely, removal of the abdominal and thoracic viscera, except the heart and kidneys: cleaning the viscera with palm wine mixed with various spices (the kinds of which are not specified): anointing the body with 'cedar oil' and other precious ointments (the kinds not being stated) and finally rubbing it with myrrh, cinnamon and other materials in order to perfume and preserve it. In another connexion, when describing the bitumen of the Dead Sea, Diodorus states[3] that 'they transport this pitch into Egypt and there sell it for the use of the embalming of the dead; for if they do not

[1] I: 7.

[2] *The Apis Papyrus* (*Demot. Pap. Wien, No.* 27). Parts of this are quoted by Myers, *The Bucheum*, I, Sir R. Mond and O. H. Myers, pp. 18–20, 60–4, 100–2.

[3] XIX: 6.

mix this with other aromatic spices, the bodies cannot be preserved long from putrefaction.'

As the two accounts are so much alike, one writer merely supplying details omitted by the other, they will be summarized and considered together, various errors and omissions being pointed out and the materials used explained and commented upon. It should not be forgotten, however, that these descriptions are of very late date and that during the interval between the first practice of mummification and the time they were written (about 3,000 years) the methods underwent considerable modifications, for instance during the Twenty-first Dynasty when the embalmers attempted to restore to the shrunken body the form it had lost, by packing under the skin linen, sawdust, earth, sand, or other materials, and that, therefore, it is not to be expected that the descriptions should be accurate in every detail for the whole period; but artificial desiccation with natron before burial, as described by Herodotus, was almost certainly the underlying principle of them all.

1. In the most expensive method, though not in the less expensive ones, the brain and the abdominal and thoracic viscera, except the heart and kidneys, were removed. This agrees in the main with the facts found from an examination of a very large number of mummies, the heart always having been left in position, and generally also the kidneys, but the brain and the rest of the viscera having been removed.[1, 2, 3] Sometimes, however, the mummies of those whose relatives would certainly have adopted the best and most expensive method of embalming in use at the time have been found that have not been eviscerated, for example that of Queen Aashaït, wife of Mentuhotep II (Eleventh Dynasty), and that of Maït (possibly a princess), who was buried with the wives of Mentuhotep, both of whom were found by Winlock at Deir el Bahari[4] and examined by Derry.[5] Pettigrew noticed a similar fact and states[6] that 'Mummies very richly furnished and prepared in the most costly manner have been found without the ventral

[1] G. Elliot Smith, (*a*) A Contribution to the Study of Mummification in Egypt, *Mém. de l'Inst. Égyptien*, v (1906); (*b*) *The Royal Mummies*.

[2] W. R. Dawson, Making a Mummy, *Journal of Egyptian Archaeology*, xiii (1927), pp. 40–9.

[3] G. Elliot Smith and W. R. Dawson, *Egyptian Mummies*, pp. 146–7.

[4] H. E. Winlock, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1920–1921*, pp. 36–42.

[5] D. E. Derry, Report upon the Examination of Tut-ankh-Amen's Mummy, *The Tomb of Tut-ankh-Amen*, Howard Carter, II, p. 146.

[6] T. J. Pettigrew, *History of Egyptian Mummies*, p. 60.

incision.' A mummy found in Nubia had all the abdominal organs removed, but there was no ventral incision.[1]

2. The viscera from the abdominal and thoracic cavities were cleaned with palm wine and spices, operations that naturally have not left any traces.

3. The body cavities were filled with myrrh, cassia and other aromatic substances and the embalming incision then sewn up. Herodotus specifically states that these operations took place before the natron treatment and, although Gannal,[2] Pettigrew,[3] Elliot Smith and Warren Dawson[4, 5] doubt this, it seems not unreasonable to think that an attempt may have been made to keep the body fragrant while it was undergoing treatment by putting in, temporarily or permanently, certain aromatic materials. The embalming incision, however, has rarely been found sewn up,[6] and neither myrrh nor cassia have been identified with certainty from the abdominal or thoracic cavities. The principal packing materials found have been linen, linen and resin, sawdust, sawdust and resin, earth and natron,[7] lichen, and occasionally one or more onions.

4. The body was treated with natron. This is mentioned only by Herodotus.

5. The body was washed. This also is mentioned only by Herodotus, but it seems most natural and likely, and certainly was generally carried out. I have suggested already that the greater deterioration that is often seen in the bandages nearest the body, as compared with those on the outside, may have been brought about in the first place by fungus, the growth of which would be due to the body's having been wrapped up while still damp.

6. The body was anointed with 'cedar oil' and other precious ointments, and then rubbed with myrrh, cinnamon and other fragrant material. This is mentioned only by Diodorus, but in view of the great part played by the use of oil and ointments for the living, some anointing of the dead seems practically certain.

[1] F. Wood Jones, Arch. Survey of Nubia, Report for 1907–1908, *The Human Remains*, p. 207.

[2] J.-N. Gannal, *Histoire des embaumements*, 1838, p. 81.

[3] T. J. Pettigrew, *op. cit.*, pp. 83–4.

[4] G. Elliot Smith and W. R. Dawson, *op. cit.*, p. 61.

[5] W. R. Dawson, *op. cit.*, p. 43.

[6] G. Elliot Smith and W. R. Dawson, *op. cit.*, pp. 61, 100, 103, 119.

[7] Specimen analysed by me from a body under examination by Dr. Derry, and probably about Twenty-second Dynasty date. (H. E. Winlock, *op. cit.*, pp. 35–6).

7. In the second method described by Herodotus, which was the middle and less costly way, cedar oil was injected into the body and prevented from escaping until the end of the natron treatment.

8. In the third method described by Herodotus, which was for the poorer classes, the nature of the injection employed for cleaning out the intestines is not stated, but almost any liquid, even plain water, if used in sufficient quantity, would have been effective.

It may be pointed out that in the description given by Herodotus natron and not salt is definitely stated to have been the drying agent used. Washing is mentioned by Herodotus, and anointing by Diodorus, but neither refers to the use of a bath, nor of artificial drying (other than that implied by the use of natron), which, if these were employed, is most astonishing.

The method of embalming the sacred bulls, as practised during the Twenty-sixth Dynasty, given in the Apis Papyrus, apparently was similar to the second method of Herodotus, namely, injection *per anum*. There is not any mention of a bath, and solid natron was employed, though the manner of its use is not clear. The bodies of the bulls found by Myers at the Bucheum at Armant were so badly preserved that practically nothing was left except bones. Several embalming tables of late date for use in connexion with the embalming of the sacred bull Apis have been found recently by Dr. Ahmed Badawy at Memphis, some of them being alabaster and some of limestone.[1]

The materials mentioned by Herodotus and Diodorus as having been employed in the mummification process, as also certain materials stated by Pliny to have been used by the Egyptians for embalming, and those found in recent times in connexion with mummies, taking them in alphabetical order, are: beeswax, bitumen, cassia, cedar oil, *cedri succus*, *cedrium*, cinnamon, gum, henna, juniper berries, lime, natron, ointments, onions, palm wine, resins (including gum-resins and balsams), salt, sawdust, spices, and wood tar or wood pitch, all of which will now be considered, except lime, natron and salt, which already have been dealt with.

Beeswax

Beeswax, which will be dealt with more fully in connexion with oils and fats, was often employed in mummification for covering the

[1] Not yet published.

ears, eyes, nose, mouth and embalming incision[1, 2] and eleven specimens of such material have been examined by me, the results of eight of which have been published[3]: beeswax was also employed on other parts of the body, thus in the case of a female mummy (No. 23) of the Eleventh Dynasty found by Winlock at Deir el Bahari, which Dr. Derry kindly allowed me to examine, there was a brown incrustation, about one to two millimetres thick, on the thighs and on the back, which on analysis proved to be beeswax.

Bitumen

From a study of the literature of mummification there would seem at first thought to be no doubt whatever that natural bitumen (pitch) from the Dead Sea was employed extensively in Egypt in the preservation of the dead, thus both Diodorus[4] and Strabo,[5] when referring to the Dead Sea, state that the bitumen from it was used by the Egyptians for embalming, though the former makes no mention of it in his detailed description of the embalming process[6] and all modern writers on mummification until recently also state that bitumen was used. But I queried this some years ago,[7] and my views on the subject (namely, that bitumen was certainly never employed for mummification until Ptolemaic times at the earliest, when possibly it may have been used) seem now generally to be accepted, thus Ruffer, writing after he was aware of my opinion, says,[8] ' It is a peculiar fact that I have never yet found bitumen in any mummy, and my experience now extends from Prehistoric to Coptic times '; and Dawson writes[9] ' . . . bitumen,

[1] G. Elliot Smith, *Mém. de l'Inst. Égyptien*, v (1906), p. 28.

[2] G. Elliot Smith and W. R. Dawson, *op. cit.*, pp. 113, 117, 124.

[3] A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, p. 53.

[4] XIX: 6. [5] XVI: 11, 45.

[6] Herodotus, however, although he refers to bitumen on several occasions, and describes the methods and materials used by the Egyptians in embalming, does not mention bitumen as having been employed. Pliny, too, also frequently refers to bitumen, but says nothing about its use in mummification, though he mentions other materials that were so used, and Josephus and Tacitus both describe the Dead Sea and the occurrence of bitumen, but do not refer to any use of it for embalming.

[7] A. Lucas, (*a*) *Arch. Survey of Nubia, Report for 1907–1908*, II (1910), pp. 372–4, (*b*) *Preservative Materials used by the Ancient Egyptians in Embalming* (1911); (*c*) *Journal of Egyptian Archaeology*, I (1914), pp. 241–5; (*d*) *Ancient Egyptian Materials* (1926), pp. 122–4.

[8] M. A. Ruffer, *Histological Studies on Egyptian Mummies*, in *Mém. de l'Inst. Égyptien*, VI, fasc. III (1911), p. 6, footnote dated March 1911.

[9] W. R. Dawson, *op. cit.* (1927), p. 46.

although described in modern books as the staple embalming material, was never used until Graeco-Roman times, and, if then, by no means universally.' The mistake has been due to the facts that much of the material, especially from the later mummies, is black and looks very like bitumen and that no systematic examination by modern chemical methods was made. The only results that can be traced where such methods have been employed are by Reutter, by Spielmann, by Griffiths and by myself.

Reutter analysed six specimens of Egyptian mummy material in all of which he states that bitumen was present.[1] Three of these specimens were from human mummies (one of the Thirtieth Dynasty and two undated); one was from a bird mummy (ibis) also undated; one consisted of a bundle of bandages from bird mummies (undated) and one was from a canopic box (undated). The first of these is very late and falls within the period when bitumen might have been used and the rest also may be late and within the same period. Also, if bitumen were used, it seems much more likely to have been for non-human mummies, such as those of birds, than for human mummies, since it was probably a cheaper material than resin. The specimen from the canopic box may not have been the material used for preserving the viscera, but an anointing substance poured over them after they had been put into the box, as was sometimes done[2] and, though the finding of bitumen in it would be of interest, its classification as an embalming material may be incorrect. The tests relied upon by Reutter for the identification of bitumen were (*a*) that a blackish coloured residue that he separated from the material (in one instance by means of carbon disulphide) contained sulphur; (*b*) that in one instance this residue reduced sulphuric acid to sulphurous acid when heated and (*c*) that in one instance the residue had a bituminous smell. It is true that bitumen contains sulphur, but so do other materials: the production of sulphurous acid when the blackish residue was heated with sulphuric acid is in no way a test for bitumen, as the same reaction occurs when carbon or almost any carbonaceous matter is treated in this manner. To test for sulphur after having dissolved the material in carbon disulphide and evaporated

[1] L. Reutter, (*a*) *De l'embaumement avant et après Jésus-Christ* (1912), pp. 45, 50, 56, 66, 67; (*b*) *De la Momie ou Mumia*, in *Bull. des sciences pharmacologiques*, Paris (no date), pp. 49–58; (*c*) *Analyse d'une masse résineuse égyptienne ayant servi à l'embaumement d'animaux sacrés conservés au Musée de Neuchâtel*, in *Sphinx*, XVII (1913), pp. 110–4.

[2] See p. 359.

off the solvent is unwise, as carbon disulphide often contains free sulphur, and to depend upon the smell for the recognition of bitumen is most unsatisfactory. By means of these same tests Reutter also identified bitumen in ancient Egyptian perfumes,[1] though it seems a most unlikely material to have been used for such a purpose.

Spielmann[2] relied upon the most modern methods for the detection of bitumen, namely, the behaviour of the specimens when exposed to ultra-violet rays and the spectroscopic analysis of the ash. The first of these methods had been tried previously by me with various resinous materials (two predynastic, three early dynastic, one Twentieth Dynasty and three of amber) with a view, if possible, to differentiate between them and so to separate them into groups according to their botanical origin; but unfortunately it has not yet been possible to continue the work, although the results were interesting and in some instances promising.

The specimens examined by Spielmann were all supplied by me and were as follows: namely, three of modern bitumen of Judea; one of modern wood pitch; one of probable wood pitch from a mummy (undated); four resins, manifestly without any admixture of bitumen; three from ancient graves and one from an ancient jar, but only one of them from a mummy (Ptolemaic) and five pitch-like materials all from mummies (one Twentieth Dynasty; one Twenty-first Dynasty and three Ptolemaic), all of which are late, three falling within the very late period when bitumen may have been used.

Spielmann states that the appearance of the specimens when exposed to the ultra-violet rays show that the black mummy materials 'occupy positions between the undoubted bitumens and the undoubted resins.' Although this is true, it has not necessarily any significance with respect to the presence or absence of bitumen, and Spielmann only suggests that it raises 'the expectation that the presence of bitumen would become substantiated by further work rather than disproved.'

The results of the spectographic analysis showed that the elements characteristic of bitumen were vanadium, nickel and molybdenum: the resins were free or almost free from these three elements and the black mummy materials contained vanadium varying from a very slight trace to a heavy trace and nickel and molybdenum from none to a

[1] See pp. 109–10.

[2] P. E. Spielmann, *To what extent did the Ancient Egyptians employ Bitumen for Embalming*, in *Journal of Egyptian Archaeology*, XVIII (1932), pp. 177–80.

heavy trace. A specimen of north European wood pitch did not contain any of the three elements in question.

If Dead Sea bitumen always contains vanadium, nickel and molybdenum (which is highly probable), then it follows that any mummy material without all three of these tell-tale elements cannot contain bitumen and, therefore, two of the specimens at least (one Twenty-first Dynasty and one Ptolemaic) are free from bitumen. With respect to the other three specimens, which contain all three of the tell-tale elements, Spielmann thinks there is 'strong evidence' for the presence of bitumen, and he suggests that the materials consist of wood pitch containing bitumen in 'a relatively low proportion . . . because the characteristic metals are not very pronounced' and also containing resin in 'a relatively low proportion . . . because the ochre fluorescence is not strong.' But it seems unreasonable to have added bitumen to wood pitch and likely, if bitumen had been employed, that it would either have been alone or in large proportion in any mixture. Also the results of my analyses of these same specimens[1] have not been taken into account. Thus, all the five black mummy materials were free from anything soluble in petroleum spirit, except fatty matter, derived from the bodies with which they had been in contact, whereas the specimens of genuine bitumen contained from 38.80 to 53.70 per cent of soluble matter. Again, three of the black mummy materials contained only 0.92, 1.45 and 1.93 per cent of sulphur respectively,[2] whereas two of the genuine bitumens contained 8.58 and 8.85 per cent respectively of sulphur,[2] and in the black mummy materials there was an absence of any smell suggestive of bitumen and an absence also of the fluorescence when the materials were dissolved in various solvents that is so characteristic of bitumen, and the colour and smell of the matter extracted by solvents were not those of bitumen. Possibly, however, if a considerable number of specimens of material of late date were examined definite proof of bitumen might be found,[3] and as stated some years ago, I regard 'as likely the occasional use of bitumen about the Ptolemaic period.'[4]

[1] A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, pp. 39, 43.

[2] The other specimens were not examined for sulphur. A. Tschirch and E. Stock (*Die Harze*, II. Band, 2. Hälfte, 1. Teil, p. 997) give the amount of sulphur in Syrian bitumen as 6.1% to 10.1%.

[3] Ahmed Zaki and Zaki Iskander report bitumen from a mummy of Persian date (525 to 332 B.C.). *Annales du Service des Antiquités de l'Égypte*, XLII (1943), pp. 223–50.

[4] A. Lucas, *Ancient Egyptian Materials* (1926), p. 123.

In two of the four specimens of black material analysed by Griffiths[1] he states that mineral bitumen is absent; in a third instance he says that ' the low proportion of sulphur would seem to exclude the presence of mineral bitumen,' while the fourth specimen was wood pitch ' with possibly a small addition of mineral bitumen.' As previously stated, it seems unreasonable and most unlikely to have added bitumen to wood pitch and likely, if bitumen had been employed, that it would either have been alone or in large proportion in any mixture.

In the Demotic text of one of the Rhind papyri (Ptolemaic period) the name of one of the materials mentioned as being employed for filling the cranial cavity is translated by Möller as *syrischer Asphalt*[2] (Syrian asphalt) and Brugsch had previously translated it as *syrisches Salz*[3] (Syrian salt), but both of these are guesses, the exact meaning of the Demotic word used being unknown, and in my opinion it is more likely to mean resin, a much more important Syrian product to the Egyptians than either asphalt or salt, and one known and used in Egypt from a very early date. Dr. J. Černý informs me that the same word is employed to describe a certain material used for covering or coating coffins, which may have been either the varnish so common on coffins of a late date (Twentieth to about the Twenty-sixth Dynasties),[4] which consists of resin, possibly obtained from Syria or through Syria, or the black anointing material to be described later.[5]

In this connexion about twenty masses of black material, ranging in size from that of a fist to that of a child's head, found by Professors Menghin and Amer at Ma'adi near Cairo,[6] may be mentioned, although there is no suggestion that it was used for mummification. This material was reported by Dr. J. Gangl[7] of Vienna as asphalt ' very similar to that produced in Syro-Palestine.' Dr. Gangl's analysis was limited to the determination of the solubility in certain organic solvents, the determination of the ash and the determination of the fact that it neither softened nor melted at 150° C. I examined the

[1] J. G. A. Griffiths, ' Resins ' and ' Pitch ' from Ancient Egyptian Tombs, *Analyst*, 62 (1937), pp. 703–9.

[2] G. Möller, *Die beiden Totenpapyrus Rhind des Museums zu Edinburg*, 1, p. 3, l. 8.

[3] H. Brugsch, *A Henry Rhind's Zwei Bilingue Papyri*, 1, p. 3, l. 4.

[4] See p. 407.

[5] See p. 360.

[6] O. Menghin and M. Amer, *The Excavations of the Egyptian University in the Neolithic Site at Ma'adi*, Second Preliminary Report (Season 1932).

[7] In another report in *Journal Royal Anthrop. Inst.*, LXVI (1936), pp. 65–9, the name is spelled Gange.

material much in the same manner as Dr. Gangl, at first limiting the determination to its general characteristics and behaviour and its solubility in various organic solvents, from the results of which I concluded that it was an oleo-resin from which the oil of turpentine had been lost, and I so reported it to Professor Menghin. As the result of further work, however, and additional experience of such materials, I now know that this method of examination, although necessary and useful as a preliminary measure, must be supplemented by further analysis, since by itself it yields results that lend themselves to a wrong interpretation. Before a final conclusion can be reached, the material must be saponified, acidified and extracted with solvents. Such an additional examination was made subsequently, with the result that the material was found to be wholly, or mainly, fatty matter, which had become oxidized and partly decomposed, a result that would, I am sure, be confirmed by Dr. Gangl. Since the material was practically insoluble in petroleum spirit it could not possibly be mineral bitumen (asphalt). Many years ago I pointed out that mummy tissue sometimes becomes so changed with age that it has the appearance of resin and behaves with solvents in the same manner as resin.[1]

Cassia and Cinnamon

Cassia and cinnamon will be considered together for reasons that will be apparent.

One difficulty encountered when dealing with ancient materials is that not infrequently the same name has been applied to different substances at different periods, cassia and cinnamon being cases in point, the cassia of the ancients sometimes having been the modern cinnamon.

Cassia and cinnamon are very similar to one another, both being the dried bark of certain varieties of laurel that grow in India, Ceylon and China (cassia being from *Cinnamomum cassia* and cinnamon from *Cinnamomum zeylanicum*), cassia, however, being more pungent, more astringent, less delicate in flavour and thicker than cinnamon. Anciently both cassia and cinnamon consisted, not only of the bark, but included also flower-tops, twigs and wood. The leaves were called *malabathrum*.[2]

[1] A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, 1911, pp. 50–2.

[2] E. H. Warmington, *The Commerce between the Roman Empire and India*, 1928, pp. 186–8.

The earliest references to cassia that can be traced in the ancient Egyptian records are in the Papyrus Harris of the Twentieth Dynasty, where both cassia and cassia wood are mentioned,[1] and the earliest references to cinnamon are in the Eighteenth[2] and Nineteenth[3] Dynasties respectively, where it is stated that it was obtained from Punt and, though cinnamon is not a product of Punt, it might well have reached Egypt through that country. Cinnamon and cinnamon wood also are mentioned frequently in the Papyrus Harris.[4]

Both cassia and cinnamon were well known to the Greeks and Romans and are described by Herodotus,[5] Theophrastus,[6] Dioscorides,[7] Pliny[8] and other writers, Pliny stating that cinnamon 'grows in the country of the Ethiopians,' which, however, is not so.

In the ancient Egyptian records the use made of cassia and cinnamon is not specified, but naturally they would have been employed as flavouring and perfuming materials and also possibly as incense, and as already shown Herodotus mentions cassia and Diodorus mentions cinnamon (possibly the same material being meant in both cases) as having been used in mummification.

Two references to the finding of cassia or cinnamon in connexion with mummies can be traced, one by Osburn, who says of a mummy (probably of the Twentieth Dynasty) that 'a thick layer of spicery covering every part of it . . . this external covering, which is nowhere less than an inch in thickness and which is interposed everywhere between the bandages and the skin . . . still retains the faint smell of cinnamon or cassia . . . but when mixed with alcohol or water and exposed to the action of heat the odour of myrrh becomes very powerfully predominant.'[9] This is quoted by Pettigrew,[10] who also says of a mummy he had examined, 'I have seen the cavity merely filled with dust of cedar, cassia, etc. and an earthy matter.'[11] Neither of these identifications can be considered satisfactory or final.

[1] J. H. Breasted, *op. cit.*, IV, 234, 344, 379.
[2] II, 265.
[3] III, 116.
[4] IV, 234, 240, 287, 300, 344, 348, 378, 391, 394.
[5] III: 107–11.
[6] IX: 5, 1–3.
[7] I: 12, 13.
[8] XII: 41–3.
[9] W. Osburn, *An Account of an Egyptian Mummy presented to the Museum of the Leeds Philosophical and Literary Society* (1828), p. 6.
[10] T. J. Pettigrew, *op. cit.*, p. 60.
[11] T. J. Pettigrew, *op. cit.*, pp. 62–3.

Cedar Oil, Cedri Succus, Cedrium

These three materials have been dealt with by me elsewhere,[1] and it has been shown that the substance referred to by both Herodotus and Diodorus and translated ' oil of cedar ' was probably not a cedar product, but a juniper product, and, as the writers are at variance with respect to the method of its application (one stating that it was injected and the other that it was employed for anointing), either two different substances were meant or one or other was mistaken. Since there is no certainty about the manner in which the ' oil of cedar ' was used (each method requiring a different material) it is impossible to be sure of its nature. If injected, it was probably either impure oil of turpentine or pyroligneous acid containing admixed oil of turpentine and wood tar, and if employed for anointing, it was probably some ordinary oil perfumed by volatile oil of juniper. In neither case could it have been a fixed oil of any coniferous tree, since no such oil was then known. The use of ' cedar ' oil in connexion with burial was continued certainly as late as the end of the first century A.D.[2] The present day ' cedar ' oil is a product obtained by distillation (a process not known until a late date) from the American juniper (*Juniperus virginiana*).

The *cedri succus* (cedar juice) of Pliny[3] was the natural resinous exudation of some coniferous tree, probably never the cedar, but often the juniper, and for the extensive use of some such material by the Egyptians in embalming there is ample evidence.

Cedrium, as defined by Pliny,[4] was pyroligneous acid containing admixed oil of turpentine and wood tar, for the use of which no Egyptian evidence has been found. The term *cedrium*, however, might not unreasonably have been used to mean wood tar alone, which was sometimes employed by the Egyptians for embalming.[5]

Henna

Henna has been mentioned already in connexion with cosmetics and perfumes,[6] where it was suggested that the flowers, which are odoriferous, probably were employed in ancient Egypt for perfuming

[1] A. Lucas, *' Cedar '-Tree Products employed in Mummification*, in *Journal of Egyptian Archaeology*, XVII (1931), pp. 13–21.
[2] B. P. Grenfell and A. S. Hunt, *The Amherst Papyri*, II, p. 150.
[3] XXIV: 11. [4] XVI: 21. [5] See p. 376. [6] See p. 107.

unguents and also that the leaves were used as a cosmetic to colour the palms of the hands, the soles of the feet and the hair, as is done to-day.

The henna plant (*Lawsonia alba, Lawsonia inermis*) is a perennial shrub that is largely cultivated in Egypt; it is grown in gardens for its strong smelling flowers and as a farm crop for its leaves, the chief use of which is as an article of toilet, a paste being prepared from them with which the hands, feet, nails and hair are coloured red: a decoction of the leaves is stated to be used occasionally for dyeing cloth.

That the finger and toe nails of mummies sometimes are stained has often been noticed. Thus Rouyer says[1] that certain mummies had the palms of the hands, the soles of the feet and the nails of the fingers and toes stained red with henna. This is quoted by Pettigrew, who says[2] that 'Mr. Davidson's mummy presented this stained appearance on the nails. Mr. Madden also says that the hands of many were dyed with the juice of the henna.' Naville states[3] that the finger nails of an Eleventh Dynasty mummy were tinted with henna and Maspero thought that the hands of Ramesses II were stained 'jaune-clair par les parfums.'[4] Elliot Smith, suggests, however, that the discoloration had been caused by the embalming material, which may have also been the case with the mummy to which Naville refers, as it almost certainly was with the staining of the nails of a number of mummies examined by the author. Pettigrew well sums up the matter as follows[2]: 'The nails of the fingers and toes of some mummies have been observed to be stained, as if with henna . . . Whether this be really the case is not at all clear; the colour may probably be produced by the medicaments employed in the process of embalming.' Elliot Smith describes the hair of the mummy of Henttawi (Eighteenth Dynasty) as being dyed a brilliant reddish colour, which he suggests had been done with henna.[5] Brunton suggests[6] that a light brown-red colour of the hair of an old woman of Badarian date might be due to henna and he also says that an oldish woman of the Pan-grave period 'had long henna-stained nails.'

[1] P. C. Rouyer, *Notice sur les embaumemens des anciens Égyptiens*, in *Description d'Égypte, Antiquités, Mémoires*, I (1809), pp. 207–20.
[2] T. J. Pettigrew, *op. cit.*, p. 66.
[3] E. Naville, *The Eleventh Dynasty Temple at Deir-el-Bahari*, I (1907), p. 44.
[4] G. Elliot Smith, *The Royal Mummies*, pp. 60–1.
[5] G. Elliot Smith, *op. cit.*, p. 19.
[6] G. Brunton, *Mostagedda*, pp. 45, 123.

Borchardt points out[1] that the finger and toe nails of statues are sometimes painted red.

Juniper Berries

Juniper berries, generally those of *Juniperus phœnicea*, but sometimes *J. drupacea*, have frequently been found in ancient Egyptian graves, the earliest that can be traced being one berry, of which the species was not determined, from the predynastic period.[2] Schiaparelli found juniper berries in a tomb of the Eighteenth Dynasty[3]; I have identified a large number from the tomb of Tut-ankhamun, where four baskets were filled with them, in two baskets the berries being small and in two baskets larger; Kunth found them among the Passalacqua collection[4]; Loret mentions specimens from two tombs at Thebes[5]; Newberry identified 'a quantity of twigs . . . to which in a few cases the berries were still attached' from crocodile mummies found by Petrie at Hawara[6]; in the description of the Christian bodies found in Nubia, Elliot Smith and Wood Jones mention 'little round berries,'[7] which I saw at the time and believe to have been juniper berries, and in a report dealing with some of this material I state[8] that 'In Nubia, in a cemetery thought to be about . . . the fifth century A.D., the bodies . . . were packed in large quantities of salt, mixed in some instances with the same kind of small globular fruit or berries already mentioned.' This reference is to another specimen of preservative material, submitted by Elliot Smith, from a Coptic 'mummy' of the fifth century A.D. from Naga el Deir, which 'consisted of a mixture of common salt and small globular fruit or berries about the size of a pea.'[8]

Writing of the Coptic monastery of Epiphanius at Thebes, Winlock

[1] L. Borchardt, Gebrauch von Henna im Alten Reiche, *Zeitschrift für Ägyptische Sprache*, XXXV (1897), p. 168.

[2] G. Brunton, *Mostagedda*, p. 91.

[3] E. Schiaparelli, *La Tomba dell' Architetto Cha*, p. 164, fig. 148; p. 165, fig. 150; O. Mattirolo, in *Atti della Reale Accademia delle Scienze di Torino*, LXI (1926). See also R. Macramallah, *Un cimetière archaïque . . . à Saqqarah*, 1940, p. 76.

[4] C. Kunth, in *Cat. des antiquités découvertes en Égypte*, J. Passalacqua, p. 228.

[5] V. Loret, *La Flore Pharaonique*, 2nd ed., p. 41.

[6] P. E. Newberry, in *Hawara, Biahmu and Arsinoe*, pp. 48, 52.

[7] G. Elliot Smith and F. Wood Jones, *Report on the Human Remains*, in *Arch. Survey of Nubia, Report for 1907–1908*, p. 218.

[8] A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, p. 20.

says[1]: 'The body was then laid on the first grave sheet and handfuls of coarse rock salt and juniper berries were placed between the legs and over the trunk inside and outside the innermost wrappings,' and again 'berries of *Juniperus phœnicea* were common enough to be used in large quantities as an embalming agent in the graves.'

In the Cairo Museum there are both juniper seeds and berries of Twentieth Dynasty date from the 'cache' at Deir el Bahari where the royal mummies were found and also berries of the Twenty-sixth Dynasty from Qurna.

It seems manifest that when juniper berries were placed on the body this must have been done either on account of some fancied preservative effect or because they had a ritual significance. But the former reason would not have led to the putting of the berries in baskets or other receptacles in the tomb as was done sometimes and, therefore, they probably always had some symbolical meaning. To me, these berries seem to be directly connected with the 'cedar' wood used for coffins and shrines and the 'cedar' oil employed for anointing the dead body, which played such important parts in the burial of royal and other prominent personages, since, as has been pointed out elsewhere,[2] the 'cedar' oil was probably not from the cedar, but often essential oil of juniper extracted from the berries by soaking them in some ordinary fixed oil, and juniper and other coniferous woods were substituted sometimes for cedar.

Although the juniper is distributed throughout the whole of the rest of the Mediterranean region, it does not grow in Egypt, but because the berries have been found so frequently in Egyptian tombs, it has been assumed that the tree must have flourished formerly in the country, for which there is no evidence, and the same line of reasoning would prove that it must have been common in Upper Egypt in early Christian times (since it was in Upper Egypt and at a very late period that the berries seem principally to have been used), though this is most unlikely and it is much more probable that the berries, like the wood, should have been imported from western Asia. I am informed that in 1943 about one hundred small juniper trees, species not stated, about eight metres high were growing on Jebel Telleg (north of Nekhl) in Sinai.

[1] H. E. Winlock and W. E. Crum, *The Monastery of Epiphanius at Thebes*, pp. 48, 61.

[2] A. Lucas, *'Cedar'-Tree Products employed in Mummification*, in *Journal of Egyptian Archaeology*, XVII (1931), pp. 14, 15, 21.

Lichen

In the cases of the mummies of Siptah (Nineteenth Dynasty), Ramesses IV (Twentieth Dynasty) and Zadptahefonkhou (Twenty-first Dynasty) respectively, the abdomen was packed with dried lichen (*Parmelia furfuracea*).[1]

Ointments

The nature of the ' precious ointments ' mentioned by Diodorus as having been employed for anointing the body after mummification is not stated, and there is no evidence from the mummies whereby the composition can be ascertained. Several late (Ptolemaic and Roman) papyri[2, 3, 4] give a description of the religious ceremony that took place after the body had been prepared by the embalmers, but before it had been wrapped and also during the wrapping, the former of which consisted in anointing the body with certain unguents composed of odoriferous gum-resins (frankincense and myrrh) and various oils and fats (including ' cedar ' oil, boiled fat, ox fat and ointments) and another late papyrus (first century A.D.)[5] mentions among the funeral expenses the purchase of ' cedar ' oil and olive oil.

But after the mummy had been prepared, anointed and wrapped there was apparently sometimes another ceremony which consisted in pouring a liquid or semi-liquid resinous material over the mummy and sometimes also over the coffin and over the viscera after they had been put into the canopic box. This also may not unreasonably be considered an anointing. This latter treatment has been recorded in a number of instances, thus Petrie describing two Fifth Dynasty burials at Deshasheh, says[6] of one ' . . . coffin contained a woman fastened in place by some pitch poured over the body ' and of another, ' The body wrapped up lay fixed by some pitch.' Mace and Winlock state[7] with regard to the Twelfth Dynasty mummy of Senebtisi that ' Immediately inside the coffin and overlying the mummy there was a layer of some

[1] G. Elliot Smith, *The Royal Mummies*, pp. 78, 83, 113; G. Elliot Smith and Warren R. Dawson, *Egyptian Mummies*, pp. 100, 103, 122.
[2] A. Mariette, *Les papyrus égyptiens du Musée du Boulaq.*
[3] G. Maspero, *Mémoire sur quelques papyrus du Louvre.*
[4] G. Möller, *Die beiden Totenpapyrus Rhind.*
[5] B. P. Grenfell and A. S. Hunt, *The Amherst Papyri*, II, p. 150.
[6] W. M. F. Petrie, *Deshasheh*, pp. 18, 31.
[7] A. C. Mace and H. E. Winlock, *The Tomb of Senebtisi at Lisht*, pp. 17, 18.

resinous material. . . . It is clear . . . that it was poured in semi-liquid state over the mummy. . . . The purpose of this resin treatment is not easy to explain, but from the evidence of the Dahshur burials and of other graves in the same cemetery at Lisht it was not an uncommon practice of the period.' They also say, ' From coffins now in the Metropolitan Museum it is clear that a similar treatment was in use at Meir, as resin was poured over the anthropoid coffin of Hapi Ankhtifi after placing it in the second coffin and before depositing the shawls and staves.' Among the Dahshur burials to which Mace and Winlock refer was that of King Hor (Twelfth Dynasty) and de Morgan, describing the *sceptres* in the coffin, says they were *demi pris dans le bitume*,[1] and in the Cairo Museum there is beadwork from outside this body that is embedded in a pitch-like mass. At Lahun, Brunton, in his description of a burial, also of Twelfth Dynasty date, states[2] that ' The coffin was probably placed in a stone sarcophagus, as we found a lump of pitch or bitumen giving the cast of the inside at one corner and also the cast of part of the head of an anthropoid coffin, with head-dress painted in stripes of blue and gold. The pitch had been poured over the sarcophagus after the burial in order to protect it.' Brunton also found in another tomb of the same dynasty (Twelfth) at Lahun certain canopic jars, the black material in which he describes as ' bundles of cedar pitch adulterated with mud.' [3] Elliot Smith, in his report on the mummy of Senebtisi, states[4] that two of the canopic jars contained a black resinous mass. Three of the canopic jars from the so-called ' Tomb of Queen Tiy ' also contained a black, very pitch-like substance that had been poured over the packets of viscera. In the case of Tut-ankhamun, a similar-looking material had been poured in large amount over the mummy (except the head) after it had been placed in the gold coffin; over the outside of this coffin after it had been put into the next coffin and also, but only in small quantity, over the foot end of the third (outermost) coffin.[5] A considerable amount of similar material had also been poured over the four miniature inlaid gold coffins containing the viscera after they had been placed in position in the canopic box.[6] The remains of what is apparently a similar black

[1] J. de Morgan, *Fouilles à Dahchour*, Mars-Juin, 1894, p. 98.
[2] W. M. F. Petrie, G. Brunton and M. A. Murray, *Lahun II*, p. 29.
[3] G. Brunton, *Lahun I, The Treasure*, pp. 19–20.
[4] G. Elliot Smith, in *The Tomb of Senebtisi at Lisht*, p. 120.
[5] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, pp. 79, 81, 83, 85, 87, 89, 90.
[6] Howard Carter, *op. cit.*, III, p. 49–50.

or dark brown material may be seen on the inside of the canopic box of Amenophis II, on the four canopic vases of Nofertari and on other canopic vases in the Cairo Museum, and a number of large alabaster jars containing a similar-looking material were found many years ago by Howard Carter in the tomb of Menephtah, specimens of which he submitted to me for analysis.

The results of the examination of these materials, taking them in the order mentioned, may now be considered.

Petrie calls the Fifth Dynasty specimen ' pitch ' (probably meaning mineral pitch), but no evidence is given that it was mineral pitch and it seems highly probable that it was not analysed, and that the only reason for thinking it to be mineral pitch was because it looked like it.

Mace and Winlock call the Twelfth Dynasty specimens from the tomb of Senebtisi ' resinous material ' and that from the coffin of Hapi Ankhtifi ' resin,' but neither of these was analysed. In reply to an inquiry by me, Mr. Winlock says, ' My memory of the " resin " in Senebtisi is that it was a very dark-brown chocolate coloured material, approaching black, but not actually black.' [1] ' In the case of Hapi Ankhtifi the coffin was given a coating of the coal-black and shiny pitch-like material which you know on so much of the tomb furniture from the Eighteenth Dynasty; for example, the objects from the tomb of Horemheb. After the coffin had been laid in the outer coffin and the staves had been laid upon it, the liquid " resinous " material was poured over it. It had largely disfigured the coffin and was removed some time ago, but as far as my memory serves me it also was a very dark brown.' [1]

A specimen of the material from the beadwork belonging to King Hor now in the Cairo Museum examined by me was black, glossy and pitch-like, and analysis showed it to be probably resin, since no evidence of wood pitch of other admixture was obtained : it had a slight fragrant smell when burned.

The Twelfth Dynasty specimen, called by Brunton ' pitch or bitumen,' from the interior of a sarcophagus at Lahun, was examined at the time by me. I reported[2] that ' The sample has an aromatic odour with a slight pungency. The material is certainly not pitch (neither mineral pitch nor wood pitch), but is a resin, which at present has not been identified.'

[1] Private communication.

[2] W. M. F. Petrie, G. Brunton and M. A. Murray, *Lahun II*, p. 15.

The ' cedar pitch adulterated with mud ' from Lahun was identified by Sir Armand Ruffer, apparently from the smell, since he says,[1] ' The wood pitch was certainly cedar, and my whole laboratory has smelt of it ever since the hot weather has set in. The pitch was adulterated with very fine mud, to the extent of 10 per cent, or perhaps more.' I made a preliminary analysis of this material at the time and found that it was almost certainly wood pitch, though more likely juniper wood pitch rather than cedar wood pitch.

In a preliminary report on the material from the canopic vases of ' Queen Tiy,' I stated that it ' was probably wood pitch with a mixture of fatty matter, but whether resin was present could not be determined.' [2] This was analysed more fully by Griffiths,[3] who states that ' The data for this substance are consistent with wood pitch.' I found a little fatty matter in two vases, but none in a third. Griffiths did not find fatty matter.

The material from the tomb of Tut-ankhamun has been analysed both by Plenderleith and by me. Plenderleith states[4] that the specimen submitted to him consisted of a mixture of odoriferous resins and pitch, but that he was unable to determine whether the pitch was mineral or vegetable. The specimen analysed, however, was possibly not a representative one. Thus, as shown below, the material varied from a thin, brittle substance to a thick viscous one and, although both had originally been part of the same mass, it is probable that the thin layer had not merely dried, but on account of its thinness had undergone more chemical change (especially in its content of fatty matter) than the thicker layer. Also, Plenderleith's sample was almost certainly taken from some of the material after it had been melted and that may even have been partly burned, considerable heat having been applied in order to separate the gold mask from the gold coffin to which it was stuck fast by this black material, as also to separate the gold coffin from the middle coffin, which were also stuck together.[5]

My preliminary report on the Tut-ankhamun samples, which were taken by myself before there had been any manipulation and which were thoroughly representative of the various portions (which differed

[1] G. Brunton, *Lahun I, The Treasure*, pp. 19–20.

[2] A. Lucas, *The Canopic Vases from the ' Tomb of Queen Tiyi,'* in *Annales du Service*, XXXI (1931), pp. 120–1.

[3] J. G. A. Griffiths, *Analyst*, 62 (1937), p. 707.

[4] H. J. Plenderleith, *Appendix V*, pp. 215–6, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

[5] Howard Carter, *op. cit.*, II, pp. 87–8.

among themselves in the proportion of the several constituents, especially fatty matter, present) was as follows[1]: 'The anointing material . . . which contained fatty matter, was black and lustrous and in appearance closely resembled bitumen or pitch; where the layer was thin, as on the lid of the gold coffin, the material was hard and brittle, but between the gold coffin and the next outer one and under the mummy, where a thicker layer had accumulated, the interior of the mass was still soft and plastic. When cold there was little or no smell, but when warmed, a strong, penetrating, not unpleasant, but rather fragrant smell was evident. A detailed chemical analysis has not yet been possible, but the material contains fatty matter and resin and is entirely free from bitumen or mineral pitch. One specimen examined contained 46 per cent of fatty matter (now largely or wholly fatty acids), 19 per cent of a brown resin and a black brittle organic residue that has not been identified.'

Since this report was made, additional specimens have been examined (altogether eleven different samples), most of which definitely contained fatty matter, and only in one instance was this not found. Two of the specimens were tested for phenols, as evidence of wood pitch, but the results were negative, though some of the features of the material are strongly suggestive of wood pitch. It is certain from the manner in which the material has 'run' and from the fact that it is still viscous in places that it was either liquid or semi-liquid when used: it is equally certain that it contains fatty matter and that this cannot have been derived from the body, as is sometimes the case with the fatty matter found in resinous materials that have been in direct contact with bodies. It is well known, too, that fat was used for anointing and hence its use in this particular anointing mixture is not surprising.

The black material from outside the canopic coffins of Tut-ankhamun is probably of the same composition as that from the large coffins and appears to consist of a mixture of fatty matter and resin, with certainly no mineral pitch and no clear evidence of wood pitch. Griffiths[2] found that the material was largely resin, with about nine per cent of natron and some vegetable debris, partly of coniferous origin. Mineral bitumen was absent.

[1] A. Lucas, *Appendix II*, pp. 176–8, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.

[2] J. G. A. Griffiths, *Analyst*, 62 (1937), p. 707.

The black material from the tomb of Menephtah examined in my laboratory was reported as being wood pitch in two instances and resin in a third. On reviewing the analytical results in the light of greater experience of these materials, aided by the re-examination of one of the specimens (the only one left) it is found that the material resembles very closely that from the tomb of Tut-ankhamun; it has a similar fragrant smell and contains a considerable proportion of fatty matter. Griffiths[1] found that the material was probably a resin mixed with about ten per cent of fatty matter.

In a sandstone mummiform sarcophagus of the Eighteenth or Nineteenth Dynasty[2] there is a layer of black resinous-looking material about one centimetre thick, except at the head end, where it is thicker and in one place five centimetres. The material is essentially resin with a small proportion of fatty matter.

Before any final statement can be made regarding the composition of these black 'anointing' materials, a considerable amount of additional analytical work must be done, including the direct comparison of one specimen with another and with various mixtures made up for the purpose containing different proportions of resin and fatty matter, with and without wood pitch. If the material were originally black this may have been due either to the use of a resin that had been blackened (i.e. charred) during the process of heating it in order to make it sufficiently liquid for use, or to the presence of wood pitch, which is naturally black.

Onions

Ruffer states[3] that 'Onions are not infrequently found among the bandages or in the coffins of mummies of the XXIst Dynasty and even as early as the XIIIth Dynasty and onion skins were sometimes placed over the eye of the dead.' Elliot Smith also found onions on mummies (often two, but sometimes only one), in the pelvis in seven cases; in the thorax in five cases; in the external ears in one case and in front of the eyes in one case,[4] and he states[5] that in the Twentieth, Twenty-first and Twenty-second Dynasties 'onions were used freely in the process of embalming.'

[1] J. G. A. Griffiths, *Analyst*, 62 (1937), p. 707.
[2] Cairo Museum, No. J. 38167.
[3] Sir A. Ruffer, *Food in Egypt*, in *Mém. de l'Inst. d'Égypte*, 1 (1919), p. 76.
[4] G. Elliot Smith, *A Contribution to the Study of Mummification in Egypt*, in *Mém. de l'Inst. Égyptien*, v (1906), fasc. I, pp. 28, 31.
[5] G. Elliot Smith, *The Royal Mummies*, p. 64.

Palm Wine

Palm wine has been dealt with in connexion with alcoholic beverages,[1] but both Herodotus and Diodorus state that it was employed for cleaning the body cavities and viscera during the process of embalming. This must be accepted on trust, as it is not possible that any of this wine should have remained unaltered to the present time and, therefore, it cannot be found by testing. Dawson, however, says[2] that ' the presence of alcohol in some of the tissues lends support to Herodotus' statement that palm wine was used for cleaning,' but no authority for the finding of alcohol is given and manifestly there is some mistake, as it is impossible that such a volatile substance should have remained. Reutter states[3] that probably there had been palm wine in certain of the mummy material he examined because he found what he thought was a small amount of sugar, the presence of which, however, needs confirmation, as the test chiefly relied upon for its identification (the reduction of Fehling's solution) is not specific for sugar and is given by many other substances.

Resins

Resins are not now among the products of Egypt and whether they ever were produced is doubtful: they occur to the north of Egypt in the countries bordering the east end of the Mediterranean; to the south in the Sudan, Abyssinia and Somaliland and to the east in Arabia, from most of which places they probably reached Egypt anciently.

As already shown in connexion with cosmetics, perfumes and incense,[4] resin was not infrequently buried in tombs long before mummification was practised, and it was suggested that this resin was such as was being used at the time for incense. After mummification (with its accompanying considerable use of resin) became general, resin was still put in the graves, some part probably still being incense, though judging from what was found in the tomb of Tut-ankhamun, namely, resin associated in one instance with natron, some of it was probably connected with the mummification, and, in addition, in this particular tomb there were personal ornaments and other objects made of resin and resin was also used as a varnish and as a cementing

[1] See p. 31.
[2] W. R. Dawson, *Journal of Egyptian Archaeology*, XIII (1927), p. 49.
[3] L. Reutter, *De l'embaumement avant et après Jésus-Christ*, pp. 38, 50.
[4] See p. 118.

material; in this tomb, too, which it should not be forgotten was a royal one, the incense no longer consisted of true resin from Asia, but of the more odoriferous and probably much more rare and costly gum-resin from the south.[1]

As it is the subject of mummification that is now being dealt with, only those resins that have been found directly associated with mummies will be considered, all resins of the Badarian, predynastic and early dynastic periods before the introduction of mummification being omitted.

In the literature of Egyptology there are many precise statements regarding the nature of the resins used in ancient Egypt, particularly for mummification, but many of these are merely guesswork, the nature of these resins having been very little investigated and very few of them having been identified with certainty. The only comparatively recent serious attempts to study the nature of these resinous materials, of which the results have been published and can be traced, are one analysis by Professor Florence of Lyons[2]; six analyses by Dr. Louis Reutter[3]; several analyses by E. M. Holmes[4] and my own work.[5]

Florence, as the results of his analysis, concluded that the resin he examined, which was from the grave of a monkey (undated), was some kind of pine resin, though he was unable to give the particular species.

Reutter analysed six specimens of Egyptian mummy material,[3] three from human mummies (one of the Thirtieth Dynasty and two undated); one from an ibis mummy; one (consisting of a bundle of bandages) from bird mummies (undated) and one from a canopic box (undated). While recognizing the importance of this work and without in any way wishing to depreciate its value or to impugn the accuracy of the analyses, the author would like to suggest that some of the interpretations of the results may be erroneous. The first striking fact is the comparatively large number of different substances in each specimen of material examined, thus in one specimen he found storax; Aleppo resin; mastic; cedar resin; certain resins not identified; bitumen and sugar: in a second, certain resins not identified; gum or gum-

[1] A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, pp. 183–4; III, pp. 181–2.

[2] Quoted by Lortet and Gaillard in *La faune momifiée de l'ancienne Égypte*, I (1905), pp. 319–21.

[3] For reference, see p. 349.

[4] E. M. Holmes, *Pharmaceutical Journal*, XIX (1888–9), pp. 387–9.

[5] A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, 1911.

resins; storax; wood pitch; bitumen; balsam of Illurin or Mecca balsam and sugar: in a third, bitumen; sugar; wood pitch; balsam of Gurjun and possibly balsam of Illurin or Mecca balsam: in a fourth, bitumen; myrrh; possibly aloes and probably balsam of Judea: in a fifth, bitumen; myrrh; aloes and probably Mecca balsam and in a sixth, bitumen; cedar resin; the resin from *Pistacia terebinthus* and sugar. This is quite contrary to my experience and of the very large number of different specimens of resinous materials I have examined from all periods, by far the greater number have been homogeneous resins or gum-resins of well defined character and only in a comparatively few instances were they mixtures and then with fatty matter.[1]

The tests relied upon by Reutter for the identification of bitumen[2] and sugar[3] respectively have already been discussed: the tests for storax and wood pitch are satisfactory ones. For the other materials Reutter in many cases made an 'ultimate analysis,' determining the carbon and hydrogen by direct experiment and estimating the oxygen by difference (the usual method), and from the results obtained he calculated the percentage of the three elements present and from this he calculated a formula for the substance, which he then identified with the formula of a known substance. When, however, the smallness of the portion of material operated upon (from 0.02 to 0.22 gram), which did not permit of a duplicate analysis as a check, the multiplication and division of the original figures necessitated by the calculations and the fact, to take one example, that 77.42 per cent of carbon and 10.43 per cent of hydrogen represent one substance (*gurjorésène*), and 77.3 per cent of carbon and 10.2 per cent of hydrogen represent a totally different substance (*masticorésène*), and the further facts that while 71.5 per cent of carbon and 8.6 per cent of hydrogen and 71.19 per cent of carbon and 8.64 per cent of hydrogen respectively represent the same substance (B-*heerabomyrrhol*), 71.0 per cent of carbon and 8.79 per cent of hydrogen represent a different substance (not identified), and 71.6 per cent of carbon and 8.05 per cent of hydrogen still another substance (not identified), one may be pardoned for thinking there is room for mistakes in identification. In several instances, too, Reutter bases a probable identification upon the smell of the material, or upon a process of exclusion, assuming that because negative results were obtained when certain specific resins were tested for and hence were presumably

[1] A. Lucas, *Preservative Materials used by the Ancient Egyptians in Embalming*, 1911.

[2] See p. 349.

[3] See p. 365.

absent, therefore another resin, that it was thought might have been used, was probably present.

I have examined a very large number of resinous materials from mummies,[1] the results of which may now be considered. Reutter, in his criticism of this work, suggests that ' ultimate analyses ' should have been made; but unfortunately, as explained at the time, this was not possible, partly because of the small size of the specimens and also because of the lack of the necessary time and facilities. In those cases, too, in which the material had become contaminated with natron or with fatty or other decomposition products of the body, or had intentionally been mixed with fatty matter, which were a large proportion of the total number, any ' ultimate analysis ' would have been not only useless, but misleading. Since the original report was published, some of the same materials have been re-examined in greater detail and other specimens have been analysed. These resinous materials may be classified into two main groups, namely, true resins and gum-resins, which may separately be considered.

True Resins

The botanical sources of the true resins, as distinguished from gum-resins, employed in mummification, as also of those found in predynastic and early dynastic graves before mummification was practised, are unknown and since the matter is of considerable importance, the present position may briefly be stated.

Both from practical considerations and also from references in the ancient Egyptian records, there cannot be any doubt that the resins now being considered were obtained from the eastern Mediterranean region. The principal resin-bearing trees of that region are the conifers (cone-bearing trees) and the principal coniferous trees are cedars, cypresses, firs, junipers, larches, pines, spruces and yews. Of these, the yews do not produce resin, and the cypresses and junipers[2] ordinarily do not produce resin, so all these may be excluded. Also, in view of the fact that many of the resins in question were reaching Egypt as early as predynastic times, the likely countries in the eastern Mediterranean region from which they were obtained may be limited to Syria,

[1] A. Lucas, *op. cit.*

[2] A. Lucas, ' Cedar '-tree Products employed in Mummification, *Journal of Egyptian Archaeology*, XVII (1931), pp. 13–21. At the time this was written it was not realized that for all practical purposes the juniper was not a resin-producing tree.

and the south of Asia Minor. If this limitation is accepted, then the possible principal resin-bearing conifers left for consideration are the cedar (*Cedrus Libani*) from the Lebanon mountains in Syria and from the Taurus mountains in Asia Minor; the Cilician fir (*Abies cilicica*) from north Syria and Asia Minor; the Aleppo pine (*Pinus halepensis*) from north Syria and Asia Minor; the Stone or Umbrella pine (*Pinus Pinea*) from Syria, and the oriental spruce (*Picea orientalis*) from Asia Minor. The cedar, however, although it does produce resin when wounded, does not produce it readily or in great quantity, and, so far as is known to me, it has never been used as a source of resin, apart from its possible use in ancient Egypt now being considered, and, in my opinion, cedar resin may be excluded.

Since the nature of the coniferous woods from Syria and Asia Minor, but largely from Syria, that were used in ancient Egypt, may throw some light upon the trees that were known, and, therefore, possibly upon the resins, it may be mentioned that these trees, which will be considered fully in connexion with wood, included cedar, cypress, fir, juniper, pine and yew. Excluding the cypress, juniper and yew, as non-resin-bearing trees, there remain, therefore, cedar, fir and pine. The cedar was the Lebanon cedar, the fir was probably the Cilician fir and the pine was probably the Aleppo pine.

In the ancient Egyptian records a highly valued wood (*ach* wood) is mentioned as having been obtained from Syria, and *ach* resin was employed for mummification.

Taking into account the colour of the *ach* wood (light yellow) as shown on the monuments; the size, height and straightness of the tree necessitated by the uses to which the wood was put (for making temple doors; the sacred boat of Amun; masts for boats, and for temple pylons); the place (the Lebanon mountains) from which the wood was obtained, and the fact that the tree yielded resin, Loret believes[1] that the true *ach* of ancient Egypt was the Cilician fir (*Abies cilicica*) and that the ordinary *ach* was a pine, probably usually *Pinus Pinea*, but he also suggests that the word may have been employed as a general term for a certain kind of timber from Syria. Jacquemin supports Loret[2] in his contention that *ach* was Cilician fir. Glanville agrees with Loret[3]

[1] V. Loret, *Annales du Service*, XVI (1916), pp. 33–51.

[2] M. Jacquemin, *Kêmi*, IV (1933), pp. 115–8.

[3] S. R. K. Glanville, Records of a Royal Dockyard of the Time of Tuthmosis III: Papyrus British Museum 10056, *Zeitschrift für Ägyptische Sprache*, 68 (1932), pp. 8–9.

that in certain instances the word ' is not so much the name of a tree as a type of timber derived from a number of different conifers—pines and firs—but especially *Pinus Pinea*.' If *ach* wood were Cilician fir, then *ach* resin must have been from the same tree.

Adhering to the walls of a small, and otherwise empty, alabaster vase from the tomb of Tut-ankhamun, which was marked *ach* resin, there was a very small amount of material, of which I examined a specimen and found it to be a true resin, as distinguished from a gum-resin, and, therefore, it was probably from a coniferous tree. The colour varied from light brown to dark brown; it was ninety per cent soluble in alcohol; completely insoluble in turpentine and in petroleum spirit, and left a considerable amount of ash, which, however, was calcium carbonate, probably derived from the vase itself; it did not give the colour test for colophony with acetic anhydride and sulphuric acid. Unfortunately the amount of material available was too small for further tests, and certain identification was impossible.

I also examined for Dr. Reisner a specimen of what he described as ' dried cedar oil ' from Tomb No. b 2140 at Giza (reign of Chephren). This was resinous-looking, very brittle, broke with a conchoidal fracture and was almost black in colour, though the edges when viewed with a lens were red and translucent, and it gave a reddish-brown powder. It burned with a smoky flame and had when burning a very fragrant smell, leaving six per cent of ash: it was eighty-eight per cent soluble in hot alcohol; insoluble in petroleum spirit and twelve per cent soluble in turpentine. Manifestly, therefore, it was a true resin from a coniferous tree and possibly *ach* resin.

A representation of *ach* resin is shown and named in the Eighteenth Dynasty tomb of Rekhmara at Thebes: it is in small rounded lumps coloured red.[1]

Turning now to the resins used in connexion with mummification, the greater proportion of them resemble very much in appearance and general properties coniferous resins, except that most of them are insoluble in turpentine, whereas coniferous resins are largely soluble in this solvent. Of twenty predynastic and early dynastic resins specially tested, ninety per cent were insoluble, and ten per cent partly soluble in turpentine, and of twenty-two later dynastic and Graeco-Roman specimens tested eighty-six per cent were insoluble and fourteen per cent partly soluble in turpentine.

[1] G. A. Hoskins, *Travels in Ethiopia*, 1835. Plate not numbered, but between pp. 334 and 335.

It is, of course, an easy matter to assume that the ancient resins have lost their solubility in turpentine on account of age and exposure, and there is evidence that colophony does become less soluble in petroleum spirit on keeping,[1] but the ancient Egyptian resins are still largely soluble in alcohol and certain other solvents. Also, one ancient resin, approximately two thousand years old, which I believe to be Chios turpentine,[2] is still practically as easily and as completely soluble in turpentine as the fresh material.

However, taking into consideration all the various factors in the case, and admitting that there is much that at present is not understood, it seems most probable that the greater proportion of the ancient Egyptian true resins, as distinguished from the gum-resins, were from coniferous trees (firs and pines) and probably from the Cilician fir, the Aleppo pine and the Stone or Umbrella pine.

There is one coniferous resin still to be mentioned, namely sandarac resin[3] from *Tetraclinis articulata* (*Callitris quadrivalis*), which grows in north-west Africa. There is, however, no evidence and little probability that any resin from this locality was imported into ancient Egypt, and, further, the appearance of the ancient resins does not agree with that of sandarac.

Two non-coniferous resins from the eastern Mediterranean that also may be mentioned are Chian (Chios) turpentine and mastic, both from species of Pistacia, the former from *Pistacia terebinthus* and the latter from *Pistacia lentiscus*. One specimen of the former has been identified from ancient Egypt,[2] but no specimens of the latter. A species of Pistacia, probably *P. terebinthus*, is rare but scattered in Sinai,[4] and *P. terebinthus* is common in the Palestine hills north of Beersheba.[4] Another species of Pistacia, *P. Khinjuk*, is found in the Galala district (Gulf of Suez) in Egypt.[5]

One of the most noticeable features of the true resins is the considerable difference in colour among them, some being reddish (almost orange-coloured and giving a yellow powder when finely ground); others black and pitch-like in appearance; others brown and one a slate colour.

Of the reddish material, eleven specimens from mummies have been

[1] K. Dieterich, *The Analysis of Resins, Balsams and Gum Resins*, 1920, p. 161.
[2] See p. 375.
[3] Often wrongly called 'Gum Juniper.'
[4] Private letter from G. W. Murray.
[5] R. Muschler, *A Manual Flora of Egypt*, 1912, I, p. 611.

examined, seven of which were from the cranial cavity, three from the orbits and one from the nose, four being of the Twenty-first Dynasty and the others undated, but almost certainly late. The botanical source of this resin has not been identified. A resin, almost identical in appearance with the eleven specimens mentioned and having a very similar solubility in various solvents, was found in the tomb of Tut-ankhamun in a vase in the same 'kiosk' as another vase containing natron and this resin, therefore, may have had a direct connexion with the embalming.

Of the pitch-like material eleven specimens have been examined, five from human mummies (one Eighteenth Dynasty; one Twenty-first Dynasty, and three Ptolemaic); one from a crocodile mummy (undated) and five from graves (all Ptolemaic), but it is not known whether these latter were taken from the mummy or not. Four of the specimens are reported by Spielmann to contain bitumen, but as two of them are without one or two of the tell-tale elements (vanadium, nickel and molybdenum) characteristic of bitumen this seems improbable, and I think that the presence of bitumen even in the other two has not been proved.[1] The botanical source of these black resins has not been identified.

It has not been found possible to determine the cause of the black colour, nor whether the material was originally black or has become black with age, but one of the specimens, though generally black and lustrous and very pitch-like, was in part a deep brown colour and in one corner almost ruby-red, and it would seem possible, therefore, for a resin, not originally black, to become black. Of the eleven specimens mentioned, nine contained fatty matter, and it has previously been suggested that possibly the presence of fatty acids from the body may have caused certain resins to become black.[2] Another possibility is that the black colour may have been caused by the material having been charred during the heating to which it was probably subjected in order to render it sufficiently liquid to enable it to be poured over the body or into the body cavities, as the case might be.

I have examined also two preserved crocodiles,[3] both of which were black and looked as though they had been treated with bitumen. On neither did I find anything but dried and blackened flesh, with a little fatty matter in one case.

[1] See pp. 350–1.

[2] A. Lucas, *op. cit.*, p. 46.

[3] One Cairo Museum No. J. 29630; the other from the University of Michigan excavations in the Fayum.

Other black mummy materials are described in connexion with ointments and wood tar respectively.[1]

The brown specimens and the slate coloured one were ordinary resinous-looking materials, of which it has not been possible to determine the botanical source.

Gum-Resins

I have examined nine specimens of what proved on analysis to be gum-resins, all from mummies and five of them from royal mummies (two Eighteenth Dynasty, one Nineteenth Dynasty, two Twentieth Dynasty, three Twenty-first Dynasty and one Ptolemaic). These are believed to be either bdellium or myrrh (which are closely allied and very similar) and most probably myrrh.[2]

Both Herodotus and Diodorus mention the employment of myrrh for mummification: Pettigrew states[3] that 'Dr. Granville found . . . two or three small pieces of myrrh in their natural state,' and that 'Dr. Verneuil says he has been able to recognize myrrh among the balsamic substances employed in embalming,' both of which identifications appear to be largely of the nature of guesswork: Reutter reports myrrh as being present in two specimens of mummy material he analysed, one from human vertebræ and the other from a human hand, both undated.[4] Myrrh has already been described in connexion with incense.[5]

Miscellaneous Resins

Certain miscellaneous resins may now conveniently be dealt with. In one of the mummy materials examined by Reutter there were small fragments of a yellowish-brown somewhat transparent resin having an odour of turpentine, which was picked out, analysed separately and identified as probably Chios turpentine.[6] The slight solubility in alcohol, the high saponification value and the high melting point,

[1] See pp. 359, 376.

[2] With a portion of one of these specimens, which I supplied to M. R. Pfister, Professor Launoy obtained a reaction that he believes confirms the identification as myrrh. (R. Pfister, *Nouveaux textiles de Palmyre*, 1937, p. 10).

[3] T. J. Pettigrew, *op. cit.*, p. 60 *n.*

[4] L. Reutter, *De la Momie ou Mumia*, in *Bull. des Sciences Pharmacologiques*, Paris, no date, pp. 49, 58.

[5] See p. 113.

[6] L. Reutter, *De l'embaumement avant et après Jésus-Christ*, pp. 35, 36, 48.

however, are all against this. Holmes also identified as Chios turpentine a specimen of resinous material found by Petrie in a jar at Naucratis, which was dated to about the sixth century B.C.[1] Chios turpentine is an oleo-resin obtained from *Pistacia terebinthus*, a shrub or small tree that grows in southern Europe, Asia Minor, Syria and North Africa and is often called the 'turpentine tree' from the large amount of oleo-resin (turpentine)[2] that is obtained from it; and it was possibly the product from this tree to which the name of turpentine was first applied and, since the greater proportion of this material at one time on the market was collected from the island of Chios in the Grecian archipelago, it was named Chios turpentine. Petrie states[3] that a layer of Chios turpentine had been poured over the nest of three wooden coffins of Horuta (Twenty-sixth Dynasty) after they had been placed in the stone sarcophagus. No evidence is given for the identification of the resinous material. Holmes also examined a specimen of resinous material from a sarcophagus found at Hawara, dating from the second century A.D.,[4] but on account of the very small amount of material available, only few tests were possible, as the result of which he suggested that it was either benzoin or storax and probably the former.[5] That it was one or the other seems certain, since benzoic acid was given off when it was heated and, although benzoin is obtained from the Far East (Siam, Sumatra, Borneo and Java) there would not have been any insuperable difficulty in its reaching Egypt at the late date mentioned, and benzoin is a well known incense material in the East at the present day.

But resin was also employed where it served no useful purpose and where, therefore, it probably had a ritual significance. Thus in a Twenty-sixth Dynasty tomb at Matarieh near Cairo[6] a large quantity

[1] E. M. Holmes, *The Pharmaceutical Journal*, XIX (1888–9), pp. 387–9.

[2] The original name of the natural oleo-resinous exudation from the *Pistacia terebinthus*, as also from pines and certain other coniferous trees was turpentine, and it is only comparatively recently that the name of the oil (spirit) prepared from it became shortened from oil of turpentine (spirits of turpentine) to turpentine and the natural product is still called turpentine scientifically, and certain kinds are still known as turpentine commercially, for example, Chios turpentine, Venice turpentine and Strassburg turpentine.

[3] W. M. F. Petrie, *Kahun, Gurob and Hawara*, pp. 10, 19.

[4] No record of such a sarcophagus can be traced in Petrie's reports on Hawara. It seems likely that a mistake has been made and that this is the sarcophagus of Horuta (Twenty-sixth Dynasty).

[5] E. M. Holmes, *op. cit.*, pp. 387–9.

[6] Tomb No. 6 described by H. Gauthier (*Découvertes récentes dans la nécropole Saïte d'Héliopolis*, in *Annales du Service*, XXXIII (1933), pp. 27–53; Pl. VI).

(more than 50 kilograms) of resin was found between the sarcophagus (which is made of the light coloured blue-grey ' schist ' from the Wadi Hammamat, so much employed at this period) and the walls of the large hollowed-out monolithic ' case ' of limestone into which the sarcophagus closely fitted. From the results of the analysis of the resin, which have been published elsewhere,[1] it is believed to be Chios turpentine. Four other examples of the similar use of resin have come under my notice,[1] namely, (*a*) small patches of an identical-looking resin on the sides of a similar sarcophagus to that just described and of the same period in the British Museum[2]; (*b*) a mixture of resin and limestone powder used to fill up the space between a sarcophagus and an inner coffin of Twenty-sixth Dynasty date from Saqqara[3]; (*c*) a mixture of resin and broken quartz pebbles used to fill up the space between a granite coffin and a wooden one of late date from Saqqara[4] and (*d*) a mixture of resin and powdered alabaster (both coarse fragments and fine powder) used as *colle de raccord* of a Third Dynasty alabaster sarcophagus from Saqqara.[5] The limestone powder, the quartz pebbles and the broken alabaster respectively were probably used in order to economize resin.

Sawdust

Elliot Smith[6] and Elliot Smith and W. R. Dawson state[7] that sawdust, both alone and mixed with resin, has been found in the body cavities of mummies and that in one instance the skin was sprinkled with powdered aromatic wood or sawdust; in the chest cavity of the mummy of Senebtisi (Twelfth Dynasty) Elliot Smith found sawdust[8]; Verneuil found a canopic vase he examined filled with what he describes as cedar dust and natron[9]; Winlock found sawdust on several occasions

[1] A. Lucas, *Resin from a Tomb of the Saite Period*, in *Annales du Service*, xxxiii (1933), pp. 187–9.

[2] Called ' Grey basalt coffin of Wah-Ab-Ra ' and stated to have come from Campbell's tomb, *Giza*, No. 1384.

[3] Submitted by C. M. Firth and examined by me.

[4] Found by J. E. Quibell at Saqqara.

[5] Submitted by J.-P. Lauer.

[6] G. Elliot Smith, *Royal Mummies*, Nos. 61052, 61085, 61087, 61088, 61089, 61095, 61097.

[7] G. Elliot Smith and W. R. Dawson, *op. cit.*, pp. 81, 84, 114, 115, 117, 118.

[8] G. Elliot Smith in *The Tomb of Senebtisi at Lisht*, A. C. Mace and H. E. Winlock, p. 119.

[9] de Verneuil, in *Catalogue des antiquités découvertes en Égypte*, J. Passalacqua, p. 286.

among refuse embalming material from Deir el Bahari,[1] one specimen of which (from the Eleventh Dynasty tomb of Ipi) was examined by me; in another case some material tied up in a piece of woven fabric from a Twelfth Dynasty tomb found by Winlock at Deir el Bahari consisted of a mixture of fine sawdust and quartz sand[2]; among the refuse embalming material from the tomb of Yuya and Thuyu (Eighteenth Dynasty) there was at least one large jar containing a mixture of resin and sawdust.[3] Some of the sawdust examined by me has been fragrant and possibly, therefore, juniper-wood sawdust. Elliot Smith also mentions fragrant (aromatic) sawdust,[4] and Wilkinson refers to the finding at Thebes of sawdust in linen bags enclosed in earthenware jars.[5] Chopped straw has been found among refuse embalming materials.[6]

Spices

The use of spices in mummification is referred to by both Herodotus and Diodorus, but in neither instance is there any indication of the kind employed. Apart from the finding of what may have been cassia or cinnamon,[7] no reference can be traced to the presence of spices in mummies.

Wood Pitch and Wood Tar

Wood pitch and wood tar may be classed together, as they are very closely connected both in composition and in method of production, wood tar being a thick, black liquid of complex constitution produced by the destructive distillation of resinous wood, and wood pitch being the solid residue left when the liquid tar is distilled for the recovery of certain volatile constituents contained in it (chiefly acetic acid, methyl alcohol, oils and creosote).

Wood tar was known to the Greeks of the time of Theophrastus[8] (fourth to third century B.C.) and Dioscorides[9] (first century A.D.) and

[1] H. E. Winlock, *op. cit.*, 1922, p. 34; 1928, p. 25.
[2] Submitted by Dr. Derry and examined by me.
[3] J. E. Quibell, *The Tomb of Yuaa and Thuiu*, pp. 75–7.
[4] G. Elliot Smith, *Royal Mummies*, No. 61052.
[5] J. G. Wilkinson, *Topography of Thebes and General View of Egypt* (1835), pp. 256–7.
[6] H. E. Winlock, Materials used at the Embalming of King Tut-ankh-Amun, *Paper No. 10, Met. Museum of Art, New York*, 1941.
[7] See p. 354. [8] *Enquiry into Plants*, IX: 3, 1–3. [9] 1: 94.

to the Romans of Pliny's day[1] (first century A.D.) since these writers, who term the material 'pitch' (Pliny also calling it 'liquid pitch'), describe a primitive method of producing it. Hence, that wood tar or wood pitch should have been known to, and used by, the Egyptians, especially at a late date, is not surprising.

Reutter found wood tar (*goudron de bois*) in ancient Egyptian materials on two occasions, one on the mummy of an ibis (undated) and the other in the resinous material from a funerary vase (undated).[2]

Ruffer has already been quoted for the identification of 'cedar-wood pitch' of Twelfth Dynasty date from Lahun,[3] which I also examined and suggest that, although wood pitch, it was probably juniper-wood pitch and not cedar-wood pitch.

A number of specimens of ancient embalming material, chiefly from Ptolemaic mummies and often from inside the skull, which I have examined are believed to be wood pitch. Particulars of a few of these were published several years ago[4] and others have been examined since. The identification of two of these has been confirmed by Griffiths.[5]

Although wood tar is a secondary product obtained during the process of making charcoal, which was one of the important minor industries in ancient Egypt, there is no evidence that the tar produced was collected and utilized and, as the material found on, or in connexion with, mummies, is often fragrant and therefore almost certainly from coniferous woods (frequently probably juniper) which do not grow in Egypt, it seems highly probable that the wood tar or wood pitch used was imported and not produced locally.

[1] XVI: 21–2.

[2] L. Reutter, *De l'embaumement avant et après Jésus-Christ*, pp. 56, 59, 66, 68.

[3] See p. 362.

[4] A. Lucas, (*a*) *Preservative Materials used by the Ancient Egyptians in Embalming*, pp. 43, 46, 49; (*b*) in *Journal of Egyptian Archaeology*, 1 (1914), pp. 244–5.

[5] J. G. A. Griffiths, *Analyst*, 62 (1937), p. 707.

CHAPTER XIII

OILS, FATS AND WAXES

Fatty matter has frequently been found in Egyptian tombs and sometimes in considerable amount. Thus Petrie, referring to certain stone jars, says[1] 'The constant use of these jars was to contain ointment . . .' and again[2] 'Here the space was filled to three feet deep with sand saturated with ointment . . . hundredweights of it must have been poured out here . . .' It has, however, seldom been analysed, and of the few analyses of which any record can be traced none is conclusive. This inconclusiveness is inevitable as all oils and fats, unless kept under special air-tight and sterile conditions, which is not the case when placed in jars in tombs, sooner or later decompose, and as some of the bodies formed escape, either by evaporation or by soaking into the material of the containing vessel, all that the analyst has for examination, although often still looking and feeling like a fat, is merely a portion of the products of decomposition, consisting generally of a mixture of certain bodies termed 'fatty acids,' principally the solid acids, palmitic and stearic; and it is only by the separation, purification and identification of these and by a determination of the proportion in which each occurs in the mixture that the nature of the original oil or fat sometimes can be ascertained; and since what remains is generally only a part of that formed, and not necessarily a representative part, the problem may often be insoluble.

The only analyses of fatty material from Egyptian tombs that can be traced are those by Ure,[3] Friedel,[4] McArthur,[5] Chapman and

[1] W. M. F. Petrie, *Diospolis Parva*, p. 15.

[2] W. M. F. Petrie, *The Royal Tombs*, I, p. 14; W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 39–40; G. A. Wainwright, *Balabish*, p. 14.

[3] Quoted by J. G. Wilkinson, *The Ancient Egyptians*, 1878, II, p. 401.

[4] Quoted by E. Amélineau, *Les nouvelles fouilles d'Abydos*, 1895–6, pp. 275–80.

[5] Quoted by W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 39.

Plenderleith,[1] Thomas,[2] Banks and Hilditch,[3] Hilditch,[4] and myself, which may now be discussed, the most complete study of the subject being that of Banks and Hilditch.

Ure's analysis is wholly inconclusive, but in most of the other cases the material was found to consist largely of palmitic acid[6] or stearic acid[6] or of a mixture of the two, with, in some instances, small proportions of other fatty acids, of which oleic, myristic, azelaic and nonoic acids have been identified.[7] These results indicate that the particular specimens examined probably had originally been animal fats, which is confirmed in at least one instance by the archaeological evidence, which proves that the material had been in a more or less solid condition and not a liquid oil.[8]

Banks and Hilditch point out that the results found make it most improbable that any of the specimens had been castor oil, which previous to their work had been suggested for three specimens (once by Friedel, once by Thomas and once by me), since the principal constituent of castor oil is a variety of oleic acid (in the combined state) which like that contained in all the other specimens of fatty matter analysed (oleic acid being a constituent of most fixed oils and solid fats, particularly the former) would have wholly or largely disappeared.

Most of the specimens of ancient Egyptian fatty matter examined by me have consisted of solid fatty acids (essentially palmitic and stearic acids), and eleven specimens of Eighteenth Dynasty date found by Bruyère at Deir el Medineh and examined by me were of this nature, but thirteen other specimens of the same date and from the same place were different. They were all solid, some of a brown colour and others

[1] A. C. Chapman and H. J. Plenderleith, *Examination of an Ancient Egyptian Cosmetic, J. Chem. Soc.*, 1926, pp. 2614–9; also in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, Appendix IV, pp. 206–10.

[2] Quoted by A. Lucas in Appendix II, *The Tomb of Tut-ankh-Amen*, II, Howard Carter, p. 177.

[3] A. Banks and T. P. Hilditch, *A Note on the Composition of some Fatty Materials found in Ancient Egyptian Tombs*, in *Analyst*, 1933, pp. 265–9.

[4] T. P. Hilditch, *Examination of Fatty Material taken from an Egyptian Tomb at Armant*, *Analyst*, 64 (1939), pp. 867–70.

[5] A. Lucas, Appendix II, *The Tomb of Tut-ankh-Amen*, II, Howard Carter, pp. 176–7; also in *Journal of Egyptian Archaeology*, XVI (1930), pp. 46–7.

[6] Both palmitic and stearic acids are solid, white, tasteless and odourless bodies that are present in the combined state in most animal and vegetable oils and fats and form important constituents of the harder fats.

[7] In one instance succinic acid was present, but this was probably derived from some non-fatty material (almost certainly resin) mixed with the original fat.

[8] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 39–40.

orange-red, and a common feature of them all was that they were elastic. There is no doubt whatever that they were some kind of altered oil or fat, probably oil, but unfortunately the amount of material available was much too small to allow of detailed analysis. I would suggest, however, that possibly they may have been originally some kind of drying oil, such as linseed oil, or safflower oil, which under the combined effects of heat and time has polymerized to a stiff elastic solid.

A very unusual find was a small painted pottery vase discovered by Pendlebury at El Amarna,[1] which was stated by the finder to be a Cypriot type of vase. The narrow neck of the vase was blocked by an accumulation of quartz sand, a small piece of red pottery and a resinous-looking material, which latter proved on analysis to be an altered product of the contents of the vase. A small hole was drilled in the bottom of the vase, which was found to be almost full of a dark brown viscous vegetable oil, entirely soluble in alcohol, but only partly soluble in petroleum spirit. Unfortunately the identity of the oil could not be determined, though it is hoped that this may be done at some future time.

A strong smell, reminiscent of rancid coconut oil, frequently noticed in the ancient fatty materials, has led to the suggestion that the original fat had been coconut oil,[2] and the presence of palmitic acid has been taken to indicate an original palm oil,[2] but both these suppositions are demonstrably wrong, the smell being due to a very small proportion of nonoic acid, which had been formed as the result of decomposition, and palmitic acid being a constituent of most animal and vegetable oils and fats.

In the hieroglyphic records of ancient Egypt, although oils and fats are frequently mentioned, either their nature is often not stated or the meaning of the word used to describe them is unknown, and in consequence it has not yet been possible to translate many of the names.

The papyri of the Graeco-Roman period, written in Greek and found in the Fayum province, frequently also refer to oils, the Greek names of most of which are well known. The oils mentioned are castor oil [3, 4] (termed both *cici* oil and croton oil, though manifestly it cannot have been the modern croton oil); colocynth oil [3]; linseed oil [3]; olive

[1] Museum No. J. 66743.
[2] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 39–40.
[3] B. P. Grenfell, *Revenue Laws of Ptolemy Philadelphus*, pp. xxxvi, 124, 126, 129, 135, 157.
[4] B. P. Grenfell and A. S. Hunt, *The Hibeh Papyri*, I, pp. 320–3.

oil [1]; radish oil (*raphanus* oil [1, 2]); safflower oil [3] (termed *cnecus* oil and *cnecinum* and thought by Grenfell and Wright to be from the seeds of the thistle or artichoke) and sesame oil.[3]

The classical writers refer to the use in Egypt of almond oil [4]; *balanos oil* [5, 6]; ben oil [7]; castor oil [8, 9, 10, 11]; olive oil [12, 13, 14]; radish oil [11]; and several others of which the identification is uncertain.

The various oils and fats mentioned will now separately be described, which may be done conveniently in alphabetical order.

Almond Oil

Pliny mentions the manufacture in Egypt of an unguent, the Mendesian unguent, containing oil of bitter almonds, which he says was expressed in Egypt.[15] If this were so, the almonds used almost certainly were imported, for although the almond tree grows in the country, it is comparatively rare, being only cultivated at the present day in gardens in the Delta. This statement of Pliny's is the only reference that can be traced respecting the use of almond oil in ancient Egypt. The almond fruit, however, was certainly known to at least some, though probably only a slight, extent since it has been discovered occasionally in tombs, the earliest known being of Eighteenth Dynasty date, about thirty almonds having been found in a small red pottery jar in the tomb of Tut-ankhamun, and a number of stones from El Amarna being in the Museum of the Royal Botanic Gardens, Kew.[16] Schiaparelli also found almonds of Eighteenth Dynasty date at Thebes.[17] Other examples that may be mentioned are four specimens identified by Newberry from the Ptolemaic cemetery at Hawara[18] and nine that

[1] B. P. Grenfell, A. S. Hunt and D. G. Hogarth, *Fayûm Towns and their Papyri*, pp. 234–7; B. P. Grenfell and A. S. Hunt, *The Amherst Papyri*, II, p. 150.

[2] B. P. Grenfell and A. S. Hunt, *op. cit.*, VI, pp. 303–5; XVI, pp. 60–1.

[3] B. P. Grenfell, *Revenue Laws of Ptolemy Philadelphus*, pp. xxxvi, 124, 126, 129, 135, 157.

[4] Pliny, XIII: 2.

[5] Pliny, XIII: 2.

[6] Theophrastus, *Concerning Odours*, 15, 19.

[7] Pliny, XII: 46.

[8] Herodotus, II: 94.

[9] Diodorus, I: 3.

[10] Strabo, XVII: 2, 5.

[11] Pliny, XV: 7.

[12] Theophrastus, *Enquiry into Plants*, IV: 2, 9.

[13] Strabo, XVII: 1, 35.

[14] Pliny, XV: 4.

[15] XIII, 2; XV, 7.

[16] No. 47/1937.

[17] O. Mattirolo, *Atti della Reale Accad. delle Scienze di Torino*, LXI (1926).

[18] P. E. Newberry, *The Ancient Botany*, in *Kahun, Gurob and Hawara*, W. M. F. Petrie, p. 47.

have been in the Cairo Museum for many years, of which neither the place of origin nor date can be traced. The handle of a walking stick made of almond wood of Eighteenth Dynasty date, presented by Professor P. E. Newberry, is in the Museum of the Royal Botanic Gardens, Kew.

Animal Fats

Since the ancient Egyptians kept cows, sheep and goats, it is only natural that they should have been acquainted with the fat of these animals, including milk fat, and fats are mentioned in the ancient records, namely, 'butter' (Twentieth Dynasty[1]); ox fat (Eighteenth Dynasty[2]); white fat (Twentieth Dynasty, on one occasion being 'for cakes'[3]); and goose fat (New Kingdom and Twentieth Dynasty[4, 5]).

The translation 'butter' is wrong, the word so translated meaning not butter, but butter fat, the distinction between the two being a very real one. Butter is the material produced by churning milk or cream until the individual globules of fat previously in suspension coalesce; and though this fat is separated from the greater part of the liquid by straining and pressing, a certain amount of water and casein remain entangled with it, and the water naturally contains a proportion of the sugar and mineral constituents of the original milk. Butter fat, on the other hand, is made by melting butter by heat and allowing it to stand until the water and casein settle out, when the fat is poured off, and it is this that constitutes the modern Egyptian *samn* and the Indian *ghi*, which are used for eating with food and for cooking, but are never spread on bread in the manner of butter, which is entirely a custom of cold countries. The separation of butter fat from butter is a natural and unavoidable occurrence in a hot country like Egypt, especially in the summer, and the separated fat keeps much better than the original butter.

As already stated, a number of the specimens of the fatty matter from tombs that have been analysed probably originally had been solid animal fat, but so far there has been nothing characteristic left that would indicate from what particular kind of animal they were derived

[1] J. H. Breasted, *op. cit.*, IV, 233, 301, 344, 350, 376.
[2] II, 293. [3] IV, 233, 239, 299, 300, 350, 376.
[4] A. Erman, *The Literature of the Ancient Egyptians*, trans. A. M. Blackman, p. 210.
[5] J. H. Breasted, *op. cit.*, IV, 233, 376.

and it is impossible to say, for example, whether they were ox fat or sheep fat, but since it is known from the records that ox fat was largely used, this is the more probable.

With fatty material of animal origin cheese may be included, since it has recently been shown that the contents of two alabaster jars of First Dynasty date found at Saqqara was cheese.[1]

According to the Hearst Papyrus, an ointment for making the hair grow was made of gazelle fat, serpent fat, crocodile fat and hippopotamus fat,[2] and according to the Ebers Papyrus, a remedy for the same purpose consisted of the mixed fats of the lion, hippopotamus, crocodile, cat, serpent and goat.[3] Goose fat was an ingredient in many remedies.

Balanos Oil

Balanos oil, which is not now known in Egypt, was the oil expressed from the kernels of *Balanites aegyptiaca* (the Heglig of the Sudan), a tree that at one time was abundant in Egypt, but which, though it still occurs in Upper Egypt and in Kharga Oasis, is rare, and still more so in the Delta, where only a few specimens grow in gardens, though it is plentiful in the Sudan and in Abyssinia.

Theophrastus states[4] that the *balanos* was an Egyptian tree, so named from the fruit because this was shaped like an acorn (*balanos*) and that the oil chiefly used in Greece for making perfumed ointments was that of the Egyptian or Syrian *balanos*,[5] the former being the more receptive and keeping the longer and, therefore, being the more suitable for choice perfumes. Pliny states[6] that oil of *balanus* was one of the ingredients of the Mendesian unguent.

The fruit, which in appearance somewhat resembles a date, consists of a thin, brittle shell enclosing a fleshy mass, inside which is a hard kernel; this kernel furnishes the oil, which is slightly yellow in colour and is highly prized in the Sudan.

The fruits and 'stones' have been found frequently in Egyptian tombs and there are a number in the Cairo Museum stated to have been obtained from Gebelein, but unfortunately the date is not recorded.

[1] Ahmed Zaky and Zaky Iskander, Ancient Egyptian Cheese, *Annales du Service des Antiquités de l'Égypte*, 41 (1942), pp. 295-313.
[2] J. H. Breasted, *The Edwin Smith Surgical Papyrus*, I, p. 100.
[3] C. P. Bryan, *The Papyrus Ebers*, p. 153.
[4] *Enquiry into Plants*, IV: 1, 2, 6.
[5] *Concerning Odours*, 15, 16, 19.
[6] XIII: 2.

Newberry identified several hundred fruits and 'stones' of Twelfth Dynasty date found by Petrie at Kahun[1] and Quibell found stones of the same date in Upper Egypt.[2]

Ben Oil

Ben oil is the oil expressed from the nuts of *Moringa pterygosperma* (*M. oleifera*) and *Moringa aptera*, the oil from the two species being practically identical.[3] The *Moringa aptera* is a small tree with whip-like branches, scanty, minute leaves and pink flowers that grows in Egypt at the present time and is probably indigenous to the country. The refined oil has a yellowish colour, a sweet taste and is odourless and does not easily become rancid, for which reason it is much esteemed in the East for making cosmetics, for extracting perfumes from flowers and for cooking. The nuts, which are somewhat like three-sided hazel nuts (the sides being curved), consist of thin shells containing large, white, oily kernels, and are in a long pod. The nuts of *Moringa arabica* are imported into Egypt from Ceylon and southern India and are eaten by women who wish to grow fat.[4]

Ten nuts of *Moringa aptera* were identified by Newberry from the Graeco-Roman cemetery at Hawara.[5]

Castor Oil

The castor oil plant grows wild in Egypt at the present day and, since the seeds have been found in graves as early as the Badarian period,[6] the plant possibly is indigenous in the country.

Herodotus,[7] Diodorus,[8] Strabo[9] and Pliny[10] all mention the use in Egypt of castor oil for burning in lamps. Herodotus states that the seeds were either bruised and pressed, or roasted and boiled, in order to obtain the oil, which had a strong smell: Strabo states that the oil was used by the poorer people and labourers, both men and women, for anointing the body: Pliny says that in Egypt the oil was extracted without employing either fire or water, the seeds being first sprinkled with salt and then pressed. Dioscorides states[11] that castor oil was

[1] P. E. Newberry, in *Kahun, Gurob and Hawara*, W. M. F. Petrie, p. 49.
[2] J. E. Quibell, *The Ramesseum*, p. 3.
[3] Anon., *Bulletin, Imperial Institute*, 28 (1930), pp. 276–9.
[4] A. H. Ducros, *Essai sur le droguier populaire arabe de l'inspectorat des pharmacies du Caire*, in *Mém. de l'Inst. d'Égypte*, 1930, xv, pp. 39, 40.
[5] P. E. Newberry, in *Kahun, Gurob and Hawara*, W. M. F. Petrie, p. 47.
[6] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 38, 41.
[7] II: 94. [8] I: 3. [9] XVII: 2, 5. [10] XV: 7. [11] I: 38.

prepared in Egypt by grinding the seeds in a mill, putting the ground mass into baskets and pressing it.

Both castor oil and castor berries figure largely in the pharmacopoeia of ancient Egypt and are mentioned frequently as medicine in the Papyrus Ebers[1]: the oil is still largely used as a medicine at the present day and in Nubia it is used also for anointing the body and dressing the hair.

Colocynth Oil

The colocynth grows wild in Egypt principally in the desert and largely in Sinai, but it is cultivated also to a slight extent for the fruit, which contains an active principle that has considerable medicinal use. The seeds when pressed yield an oil, which is not now used in Egypt.

Lettuce Oil

The lettuce is cultivated largely in Egypt, and especially in Upper Egypt, for the sake of the oil obtained from the seeds, which is used as a salad oil and in cooking.

Linseed Oil

Flax was extensively grown in Egypt from a very early date for the sake of the fibre for making linen and probably, therefore, linseed oil (which is the oil expressed from the seeds of the flax plant) was known also at an early date, though the first record of it that can be traced is of the Ptolemaic period.[2] It was used probably for cooking and for burning in lamps, for which purposes it is still employed by the poorer classes in Egypt. The principal present day value of linseed oil is, however, as a paint oil, on account of its drying properties, but it was not employed for this purpose in Egypt, or elsewhere, so far as is known, even as late as the Roman period.

Malabathrum Oil

According to Warmington ' much malabathrum oil was produced in Egypt from raw stuff imported from India,'[3] malabathrum being the leaves of cinnamon.[3]

[1] C. P. Bryan, *The Papyrus Ebers.* [2] See p. 380.

[3] E. H. Warmington, *The Commerce between the Roman Empire and India*, pp. 186–90.

Olive Oil

In the hieroglyphic records of ancient Egypt olive trees, olives and olive oil are seldom mentioned, thus all that can be traced are as follows: two references to a sacred olive tree at Heliopolis in the Pyramid Texts (Fifth and Sixth Dynasties)[1]; a reference to olive oil, which is included among spoil from Syria; on a fragment of a wall of a mortuary temple of Fifth Dynasty date at Abusir[2]; four references to olive-lands in the Twentieth Dynasty[3, 4]; five references to olives, one of New Kingdom date[5] and four from the Twentieth Dynasty,[6] and a possible reference to olive oil[7]; also a copy of a fragment of a mural painting of the Eighteenth Dynasty showing a small part of an olive tree with several olives growing on it.[8] Reisner states that 'Olive oil was certainly imported from Palestine and Syria during Dynasty IV.'[9]

The classical writers supply additional information respecting the olive tree in Egypt, thus Theophrastus (fourth to third century B.C.) states[10] that the olive tree grew in the Thebaid, which statement is copied by Pliny,[11] and that 'The oil produced is not inferior to that of our country, except that it has a less pleasing smell . . .' Strabo (first century B.C. to first century A.D.) says[12] of the Arsinoite Nome (the Fayum) that 'It is the only nome planted with large, full-grown olive trees, which bear fine fruit. If the produce were carefully collected, good oil might be obtained, but this care is neglected, and although a large quantity of oil is obtained, yet it has a disagreeable smell. (The rest of Egypt is without the olive tree, except the gardens near Alexandria, which are planted with olive trees, but do not furnish any oil).' Pliny (first century A.D.) writes[13] that 'In Egypt, too, the berries, which are remarkably meaty, are found to produce very little oil.'

[1] L. Speleers, *Les textes des pyramides Égyptiennes*, 1923, p. 12 (par. 118); p. 21 (par. 252).
[2] L. Borchardt, *Das Grabdenkmal des Königs Sa-hu-Re*, II, 1913; Pl. 3.
[3] J. H. Breasted, *op. cit.*, IV, 216, 263, 288, 394.
[4] In one place (*op. cit.*, II, 449) Breasted translates tentatively two uncertain words in an Eighteenth Dynasty text as olive wood.
[5] A. Erman, *The Literature of the Ancient Egyptians*, trans. A. M. Blackman, p. 206.
[6] J. H. Breasted, *op. cit.*, IV, 239, 241, 379, 393.
[7] J. H. Breasted, *op. cit.*, III, 208.
[8] Nina de G. Davies, in *The Mural Painting of El-Amarneh*, Pl. IX (*c*).
[9] G. A. Reisner, *Mycerinus*, p. 251.
[10] *Enquiry into Plants*, IV: 2, 7.
[11] XIII: 19.
[12] XVII: 1, 35.
[13] XV: 4.

Mahaffy[1] and Grenfell[2] both point out that in the legislation of Ptolemy Philadelphus (285 to 246 B.C.) concerning oils and oil-pressing in Egypt there is not any reference to olive oil, commenting upon which Bevan says,[3] 'Olive trees grew in the Fayum, but olive oil does not seem to have been included in the monopoly.' The reason is not apparent, though it might possibly have been that the oil produced was too insignificant in quantity to be legislated for. Olives are mentioned in the Fayum about 257 B.C.[4] and young olive trees of the same date[5] in 256 B.C. One papyrus mentions the planting of olive shoots[6] and in another olive groves are referred to[7]; in 255 B.C. one papyrus[8] mentions the planting of olives and another[9] the planting of 3,000 shoots, and it is stated that 'the Egyptian olive is only suitable for parks and not for olive-groves'; in 251 B.C. olive shoots are mentioned[10]; olive oil is referred to in the second century A.D.[11] and olive-yards on several occasions ranging in date from A.D. 94 to A.D. 110.[12] The mere mention of olive oil, however, is not proof that it was of Egyptian origin, since, as already shown, this oil was imported into Egypt from Syria and particularly at a late date also from Greece. C. R. Scott, writing in 1837, that is during the reign of Mohammed Ali, states[13] that 'Vast tracts of land have been planted in various parts of the country with olive and mulberry trees.' In 1901, G. Bonaparte, of the School of Agriculture, Cairo, states[14] that the olive tree was only cultivated in Egypt to a very limited extent, chiefly in the Fayum and that the fruits were poor in oil. In 1927, Newberry writes[15] that the olive tree 'is only cultivated in a very few gardens in Upper Egypt at the present day.'

[1] J. P. Mahaffy, in *Revenue Laws of Ptolemy Philadelphus*, B. P. Grenfell, p. xxxv.
[2] B. P. Grenfell, *op. cit.*, p. 125.
[3] E. Bevan, *A History of Egypt under the Ptolemaic Dynasty*, p. 149 *n.*
[4] B. P. Grenfell and A. S. Hunt, *The Hibeh Papyri*, pp. 192–3.
[5] C. C. Edgar, *Zenon Papyri I*, No. 59072.
[6] C. C. Edgar, *Zenon Papyri I*, No. 59125.
[7] C. C. Edgar, *Zenon Papyri II*, No. 59157.
[8] C. C. Edgar, *Zenon Papyri II*, No. 59159.
[9] C. C. Edgar, *Zenon Papyri II*, No. 59184.
[10] C. C. Edgar, *Zenon Papyri II*, No. 59241.
[11] B. P. Grenfell, A. S. Hunt and D. G. Hogarth, *Fayum Towns and their Papyri*, pp. 234, 237.
[12] B. P. Grenfell, A. S. Hunt and D. G. Hogarth, *op. cit.*, pp. 261–74.
[13] C. R. Scott, *Rambles in Egypt and Candia*, II (1837), p. 166.
[14] G. Bonaparte, *Journ. Khedivial Agricultural Society*, III (1901), pp. 14–9.
[15] P. E. Newberry, *Appendix III*, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter, p. 195.

Ruffer saw a few, but only very few, olive trees in the oases of Dakhla and Kharga in the western desert.[1] Beadnell says[2] that '. . . olives are grown in both Kharga and Dakhla, but only in comparatively small quantities. Ball and Beadnell say[3] that '. . . olives . . . are grown in great numbers' in the oasis of Baharia. In 1923 Belgrave estimated that there were in Siwa oasis about 40,000 fruit-bearing olive trees.[4] According to the local press, the Egyptian Government recently has planted a considerable number of olive trees in the country to the west of Alexandria.

The facts enumerated seem to show that, although the olive tree grows abundantly in the countries on all sides of Egypt (across the Mediterranean to the north in Anatolia and Greece: on the north-east in Palestine and Syria: on the south in Abyssinia, where there are two kinds that grow wild, and on the west in Siwa and in Tunis and Algeria) it has never accommodated itself well to the conditions in Egypt, and that although the Greeks, who were accustomed to the cultivation of the olive tree in their own country, tried to grow it in the most likely localities in Egypt (the Fayum and the neighbourhood of Alexandria), it never really flourished and from an oil-producing point of view it has always been a failure.[5] Newberry has shown that the region adjoining the Nile Delta on the west was probably the original home of olive culture and the most ancient centre of commerce in olive oil.[6]

The evidence from the tombs for the cultivation of the olive tree in Egypt is very scanty and does not carry it farther back than the Eighteenth Dynasty, the period when Keimer states that probably it was introduced into the country.[7] The principal discoveries that can be traced are (*a*) in the tomb of Tut-ankhamun, where there was a large funerary bouquet of persea, which contained a few very small

[1] Sir Armand Ruffer, *Food in Egypt,* in *Mém. de l'Inst. d'Égypte,* I (1919), p. 81.
[2] H. J. L. Beadnell, *An Egyptian Oasis,* 1909, p. 220.
[3] J. Ball and H. J. L. Beadnell, *Baharia Oasis: its Topography and Geology,* 1903, p. 44.
[4] C. Dalrymple Belgrave, *Siwa,* p. 178.
[5] The reason for this is probably primarily the scanty rainfall on the northern coast of Egypt as compared with that in the other countries named, even as compared with Tunis and Algeria, where there are mountains near the coast that precipitate the rain.
[6] P. E. Newberry, *Proc. Linnean Society of London, Session 150, 1937–8, Pt. 1, 31 Dec. 1937.*
[7] L. Keimer, (*a*) *Die Gartenpflanzen im alten Ägypten,* p. 29; (*b*) in *Bull. de l'Inst. franç. d'arch. orientale,* XXXI (1931), p. 133.

olive twigs[1] and three wreaths partly composed of olive leaves[2]; (*b*) in the Cairo Museum there is a small twig with leaves of the olive tree marked as having been found by Schiaparelli at Thebes and dated to the period Twentieth to Twenty-sixth Dynasty; (*c*) there is also in the same museum a similar twig stated to have been found by Maspero at Gebelein and not to be earlier than the Ptolemaic period; (*d*) Braun refers[3] to olive twigs and leaves (undated) in the Berlin Museum and to funeral wreaths of olive leaves (undated) in the Leyden Museum and (*e*) Newberry identified two olive stones from the Graeco-Roman cemetery at Hawara.[4]

Radish Oil

This oil, which has a disagreeable smell, was obtained from the seeds of the radish (*Raphanus sativus*) and Pliny states[5] that the radish was held in high esteem in Egypt on account of the large amount of oil that was extracted from it. Dioscorides states[6] that the oil was used in Egypt medicinally. Although the radish is still grown plentifully in the country, the oil is no longer prepared.

Safflower Oil

Safflower oil is the oil expressed from the seeds of *Carthamus tinctorius* or false saffron, which is cultivated in Egypt at the present day chiefly for the sake of the oil, which is an agreeable, bland oil extensively used for salads and cooking.

Pliny mentions the safflower[7] which he calls by its Greek name of *cnecos*, and states that it was esteemed by the Egyptians on account of the oil it produced. Elsewhere, however, he seems to confuse the safflower with the nettle,[8] from which he says an oil (*cnidinum*, which apparently should be *cnecinum* and is *cnecinum* in anorther MS. reading)[9] was obtained.

[1] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 33.
[2] P. E. Newberry, in *Appendix III*, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter, pp. 190–1. See also H. E. Winlock, Materials used at the Embalming of King Tut-ankh-Amen, *Paper No. 10, Met. Museum of Art, New York*, 1941.
[3] A. Braun, *Journal of Botany*, 1879.
[4] P. E. Newberry, in *Hawara, Biahmu and Arsinoe*, W. M. F. Petrie, pp. 48, 52.
[5] XV: 7; XIX: 26. [6] I: 45. [7] XXI: 53.
[8] XV: 7; XXII: 15.
[9] B. P. Grenfell, *Revenue Laws of Ptolemy Philadelphus*, p. xxxvi.

The suggestion, already referred to,[1] that *cnecos* oil (*cnecinum*) was made from the seeds of the thistle or artichoke is without any support from the facts.

Sesame Oil

The sesame plant, which according to Muschler is probably of tropical African origin,[2] is grown plentifully in Egypt at the present day on account of the oil, which is expressed from the seeds. This oil is of a yellowish colour, clear and free from odour and has a bland agreeable taste. In 256 B.C. both sesame seed and sesame oil are mentioned.[3] Pliny refers to Egyptian sesame oil.[4]

Uses of Oils and Fats

Oils and fats were employed in ancient Egypt for eating, cooking and illumination; for anointing both the living and the dead; for libations; as a base for perfumes; as medicines and vehicles for medicines and doubtless for many other purposes.

In addition to the large local supply, oil also was imported from abroad to some extent from an early period and to an increasing extent later, thus in the Eighteenth Dynasty there are records of oil having been brought from Naharin,[5] Retenu[6] and Zahi,[7] all in western Asia, and in the Twentieth Dynasty from Syria.[8]

Beeswax

The only wax used in ancient Egypt, so far as is known, was beeswax, which was employed as an adhesive[9]; for permanently fixing the curls and plaits in wigs[10]; in mummification[11]; for coating painted surfaces[12]; as a paint vehicle in the encaustic process of painting[13]; at a very late date for covering the surface of writing tablets[14]; for ship-building[15] and for making magical figures.[16]

It does not seem to have been the custom to place beeswax in tombs and no record of its having been so found can be traced, but at El Amarna a piece was found in a house.[17]

[1] See p. 381. [2] R. Muschler, *A. Manual Flora of Egypt*, pp. 884–5.
[3] A. S. Hunt, J. G. Smyly and C. C. Edgar, *The Tebtunis Papyri*, III (Part II), No. 844.
[4] XV: 7. [5] J. H. Breasted, *op. cit.*, II, 482. [6] II: 473, 491, 509, 518.
[7] II: 462, 510, 519. [8] IV: 233, 376. [9] See p. 7. [10] See p. 42.
[11] See p. 347. [12] See p. 401. [13] See p. 402. [14] See p. 416.
[15] M. Rostovtzeff, *A Large Estate in the Third Century B.C.*, p. 123.
[16] Lortet et Gaillard, *La faune momifiée de l'ancienne Égypte*, II, pp. 75–8.
[17] T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 25.

CHAPTER XIV

PAINTING MATERIALS: WRITING MATERIALS

Painting Materials[1]

Pigments

The freshness and brightness of the colours of the old Egyptian tomb paintings have often been commented upon, and it is sometimes assumed that the pigments employed were such as do not exist at the present day and even that their nature is unknown. This, however, is not so, as they have been analysed frequently, and, with very few exceptions, they are either naturally occurring minerals, finely ground, or they have been made from mineral substances, to which fact is primarily due their excellent state of preservation.

The colours employed, taking them in alphabetical order, were black, blue, brown, green, grey, pink, red, white and yellow, which may be separately considered.

Black

The black pigment was almost always carbon in some form, though possibly not always in the same form; generally it is in a very finely divided condition and consists of soot (probably scraped from cooking vessels), but occasionally it is fairly coarse. Soot, however, if carelessly collected, or if collected from masonry or plaster surfaces, might be contaminated with particles of mineral matter that would give it a coarse texture.

I examined twelve different specimens of black pigment, one of the Fifth Dynasty, three of the Sixth Dynasty, seven of the Eighteenth Dynasty and one of the Twenty-third Dynasty, all of which were carbon and eleven of which were fine soot, but one of which (Eighteenth Dynasty) was coarser than is usual with soot, and unfortunately in this particular case the amount of material available was too small for any detailed analysis.

[1] A brief account of painting materials and methods is given by Mrs. Davies in *Ancient Egyptian Paintings*, 1936, pp. xxxi–xlvi.

Laurie found that a black pigment of the Nineteenth Dynasty was powdered charcoal [1]: Spurrell identified a black pigment of the Twelfth Dynasty from Beni Hasan as pyrolusite,[2] a black ore of manganese that occurs plentifully in Sinai: the bone black reported by Beke[3] needs confirmation before it can be accepted, as Beke states that the recognition was made 'without the aid of chemical analysis.' A blue-black pigment, not identified, but of which it is stated that it does 'not seem to be pounded charcoal,'[4] is known from the predynastic period, and the black pigment of the gesso-linen object from the early predynastic period, found by Myers at Armant, was carbon.[5]

Blue

The earliest blue pigment that can be traced is, as is only to be expected, a naturally occurring mineral, namely azurite (chessylite), a blue carbonate of copper that is found native both in Sinai and in the eastern desert. This was identified by Spurrell from a shell used as a palette found at Medum (Fourth Dynasty)[6] and, according to the same authority, the colour employed for painting the mouth and eyebrows on the cloth that covered the face of a mummy of the Fifth Dynasty was also azurite,[6] though he adds, 'It looks green from age and staining, which is an accident.' With respect to this same mummy, however, Petrie says,[7] 'The eyes and eyebrows were painted on the outer wrapping with green,' and Elliot Smith states[8] that 'the eyes were represented by green paint' and also[8] that 'The pupils, edges of the eyelids and the eyebrows are painted with green malachite paste.'

The principal blue pigment of ancient Egypt was an artificial frit that consisted of a crystalline compound of silica, copper and calcium (calcium-copper silicate). This was made by heating together silica, a copper compound (probably generally malachite), calcium carbonate and natron. Petrie shows that in at least one place the silica used was

[1] A. P. Laurie, *The Materials of the Painter's Craft*, pp. 26–7.

[2] F. C. J. Spurrell, *Notes on Egyptian Colours*, in *The Archaeological Journal*, LII, Second Series, II (1895), p. 229.

[3] C. T. Beke, *Of the Colours of the Ancient Egyptians*, in *Trans. Royal Society of Literature of the U.K.* (1843), pp. 48–51.

[4] J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 21.

[5] Sir R. Mond and O. H. Myers, *Cemeteries of Armant, I*, p. 131.

[6] F. C. J. Spurrell, (*a*) *op. cit.*, p. 227; (*b*) in *Medum* (W. M. F. Petrie), p. 29.

[7] W. M. F. Petrie, *Medum*, p. 18.

[8] G. Elliot Smith, *Egyptian Mummies*, in *Journal of Egyptian Archaeology*, I (1914), pp. 192–3.

in the form of quartz pebbles,[1] that were employed on account of their practical freedom from iron compounds, which if present in more than traces would have produced a green instead of a blue colour. In the original description of this frit factory,[1] 'alkali' merely is referred to, without any statement whether it was potash or soda, there being no evidence on this point, but in a later account Petrie calls it potash,[2] though no proof is given that it was potash, and since soda occurs naturally in Egypt in the form of natron (which contains traces of potash as an impurity), whereas potash would have had to be made from plant ashes, it seems much more likely that soda was used and the few analyses of this frit that have been published in no case show more than a very small proportion, if any, of potash and in one instance a comparatively large proportion of soda. Vitruvius, too, states[3] that the Egyptian blue frit (which he calls *cæruleum* and which he says was invented at Alexandria, though it was known more than 2,000 years before Alexandria was built) was made by fusing together sand, copper filings and natron (*nitri flore*). It will be noticed that Vitruvius makes no mention of calcium carbonate, which was an essential ingredient in the manufacture of the frit, but like the calcium carbonate required for making glass, this evidently was not recognized as such and, although it must have been added separately when quartz pebbles were used, this need not have been the case when sand was employed, as much of the Egyptian sand is a mixture of quartz and calcium carbonate. Theophrastus refers to a material that he calls *kyanos*,[4] which he says was invented in Egypt, that was probably this blue frit, and Pliny mentions Egyptian *cæruleum*,[5] which he calls a kind of sand, which was possibly also this frit, but the references to it are very obscure.

The composition of this frit has been investigated by many chemists beginning with Sir Humphry Davy in 1815,[6] but more especially by Dr. W. T. Russell,[7] who made specimens of it, and later by Laurie, McLintock and Miles,[8] who repeated and extended Russell's work.

[1] W. M. F. Petrie, *Tell el Amarna*, p. 25.
[2] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, p. 117.
[3] *De Architectura*, VII: 11, 1.
[4] *History of Stones*, XCVIII.
[5] XXXIII: 57–8.
[6] *Some Experiments and Observations on the Colours used in Painting by the Ancients*, in *Phil. Trans.*, CV (1815).
[7] W. T. Russell, *Egyptian Colours*, in *Medum* (W. M. F. Petrie), pp. 44–8.
[8] *Egyptian Blue*, in *Proc. Royal Society*, A 89 (1914), pp. 418–29.

The date when this frit was first used is uncertain, but it has been found as early as the Fourth Dynasty by both Spurrell[1] and Laurie,[2] the former of whom examined specimens from the Fourth, Twelfth and Eighteenth Dynasties respectively and the latter from the Fourth and Eleventh Dynasties. Soule found it in the Fifth Dynasty tomb of Per-neb[3] and I examined thirty specimens of blue colour that proved to be frit[4] (Fifth Dynasty, four[5]; Sixth Dynasty, two; Thirteenth Dynasty, two; Eighteenth Dynasty, nineteen; Nineteenth Dynasty, two; Twentieth to Twenty-sixth Dynasty, two). What is described as 'a mass of powdered blue crystalline colouring matter' was found by Reisner in the Mycerinus Upper Temple (Fourth Dynasty), but apparently it was not analysed; it is stated to be 'part of the original funerary equipment' and is described as 'the fine granular blue which is used in the wall paintings of the mastabas.'[6] It seems probable that this was the usual artificial blue frit.

In addition to its use as a pigment the frit was made into small objects, as examples of which may be mentioned a cylinder seal of the Sixth Dynasty[7]; a cylinder, also of the Sixth Dynasty[8]; a small sphinx of the Nineteenth Dynasty[9] and beads of various dates. Miss Hodgson has shown that if the frit is powdered very finely and mixed with water it can be moulded, and if then dried and fired the objects retain their shape.[10]

Laurie says of this frit that 'It was used not only in Egypt, but also in Rome in imperial times, as the universal blue for fresco-paintings,'[11] and that it 'disappeared from the artist's palette somewhere between the second and the seventh century.'[12] Specimens of this frit found in Italy may be seen in the Naples Museum.

It is stated sometimes that powdered lapis lazuli and even that powdered turquoise were employed as pigments in ancient Egypt, but

[1] F. C. J. Spurrell, (*a*) *op. cit.*, pp. 227, 228, 232; (*b*) in *Medum*, pp. 28–9.

[2] A. P. Laurie, (*a*) *op. cit.*, p. 24; (*b*) *Ancient Pigments and their Identification in Works of Art*, in *Archæologia*, LXIV (1913), p. 317. Beads of blue frit are fairly common and date back to the Fourth Dynasty.

[3] C. R. Williams, *The Decoration of the Tomb of Per-neb*, p. 27, *n.* 34.

[4] A small proportion of colourless (uncombined) quartz was found in every case.

[5] Including the blue colour in the inscriptions in the pyramid of Unas at Saqqara.

[6] G. A. Reisner, *Mycerinus*, pp. 18 (item 53), 237, 238.

[7] S. R. K. Glanville, book review in *Journal of Egyptian Archaeology*, XIV, (1928), p. 190.

[8] C. R. Williams, *op. cit.*, p. 31.

[9] In the Cairo Museum.

[10] H. C. Beck, Glass before 1500 B.C., *Ancient Egypt and the East*, 1934, p. 8.

[11] A. P. Laurie, *The Materials of the Painter's Craft*, p. 24.

[12] A. P. Laurie, *The Painter's Methods and Materials*, p. 95.

there is no evidence for the use of either and considerable probability that they were not employed. It is true that an excellent and permanent blue colour, ultramarine, may be obtained from lapis lazuli by a process of levigating the finely powdered material, but the yield is very low, being only about 2 per cent, and there is no proof that this was known until about the beginning of the eleventh century A.D. Much of the ultramarine used at the present day is an artificial product first made in the early nineteenth century. I have proved experimentally that lapis lazuli merely powdered gives a very poor bluish-grey colour. Turquoise, too, would also make a very poor pigment, and it would have been much too precious for use on the large scale required for tomb painting, even if it could have been obtained in sufficient quantity.

The use of a cobalt pigment was reported by Toch from the Fifth Dynasty tomb of Per-neb,[1] but the accuracy of this was questioned by me many years ago, and it has since been shown by Soule that the blue colour in this tomb is a calcium-copper silicate and not a cobalt blue.[2]

Sometimes Egyptian blue pigments, permanent as they usually are, have undergone a change of colour, thus the trefoil marks on the cow couch from the tomb of Tut-ankhamun, although now of a very dark brown, almost black,[3] colour, manifestly were blue originally and still show a little blue underneath the black, and as the material is granular and gives the tests for copper, it may be a deteriorated blue frit. The background of the painting of the cylindrical alabaster 'cosmetic jar' with the recumbent figure of a lion on the lid, from the same tomb, also was blue originally and was still slightly blue in places when first examined.[3] It was not found possible to take any of this pigment for analysis without damaging the object and its nature was not determined. Also in some of the tombs, for example that of Amenophis II, the blue colour has darkened in places and has become black or almost black and this does not appear to be due to smoke, which is the usual cause of blackening in tombs.

Brown

Certain brown pigments of the Fourth Dynasty examined by Spurrell were made by painting a red colour over a black, though

[1] M. Toch, *The Pigments from the Tomb of Per-neb*, in *Journal of Ind. and Eng. Chemistry*, 1918, p. 118.

[2] C. R. Williams, *op. cit.*, p. 27, *n.* 34.

[3] Since covered with melted paraffin wax and further darkened.

generally the brown consisted of ochre, a natural oxide of iron.[1] A specimen of brown pigment used for painting a box of Eighteenth Dynasty date examined by me consisted of oxide of iron and gypsum, but whether the mixture was natural or artificial it was impossible to determine, but natural mixtures of this nature are known. A good quality of brown ochre occurs in Dakhla oasis.[2]

Green

It is accepted generally that the green pigment of the ancient Egyptians owes its colour to copper and mainly two different materials were employed, one being powdered malachite (a natural ore of copper that occurs both in Sinai and in the eastern desert), which was employed for painting round the eyes as early as the Badarian and earliest predynastic periods[3] and the other was an artificial frit analogous to the blue frit already considered. A green colour of predynastic date is described as being 'bright green, granular in structure, probably pounded malachite'[4]. Spurrell records the use of malachite and malachite and gypsum in tomb paintings of the Fourth Dynasty[1] and in Twelfth Dynasty tomb paintings he found both malachite and chrysocolla (another natural ore of copper), the former predominating[5]. Soule identified the green colour from the Fifth Dynasty tomb of Per-neb as malachite.[6] I found malachite in a Fifth Dynasty tomb painting at Giza and the green on two boats from the tomb of Tut-ankhamun was not frit and may have been malachite, but the green colour in a Sixth Dynasty tomb was frit, as also were six specimens from the Eighteenth Dynasty, one from the Nineteenth Dynasty and one from the period Twentieth to the Twenty-sixth Dynasty. A green coloured plaster from a stick of Eighteenth Dynasty date was found to owe its colour to a mixture of blue frit and a yellow colour that was not identified, but which was not yellow ochre and which was probably an organic material. Spurrell, who examined the pigments from certain Twelfth Dynasty tombs at El Bersheh for Newberry, stated that the green was chrysocolla in some instances and a mixture of blue frit and

[1] F. C. J. Spurrell, in *Medum*, p. 29.
[2] H. J. L. Beadnell, *Dakhla Oasis*, p. 100.
[3] See p. 99.
[4] J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 21.
[5] F. C. J. Spurrell, in *The Arch. Journal*, LII, Second Series, II (1895), p. 227.
[6] C. R. Williams, *op. cit.*, p. 26, *n.* 24.

yellow ochre in others,[1] and Layard states[2] that the Egyptian green was ' a mixture of yellow ochre with the vitreous blue.'

Grey

The ancient Egyptian grey pigment was generally a mixture of black and white, in the Fifth Dynasty tomb of Per-neb being a mixture of gypsum and charcoal,[3] and Spurrell found a grey pigment from the Fourth Dynasty to consist of a mixture of a pale yellowish earth and lamp black.[4]

Pink

A pink colour was not uncommon in the New Kingdom, thus it is recorded from the tomb of Amenemhet (Eighteenth Dynasty)[5] and from the tomb of Menkheperrasonb[6] and I have noticed it in the tomb of Nefertari (Nineteenth Dynasty) where it was used to a considerable extent. Glanville states[7] that ' in the New Kingdom pink colour was regularly obtained by simply mixing red and white,' but no reference is given to any analysis. The pink, however, at this date was certainly due to oxide of iron. A pink colour from a tomb painting of the Graeco-Roman period was identified by Russell as consisting of madder (obtained from the roots of the madder plant, a native of Greece, often called Turkey red) on a base of gypsum[8] and a similar shade of colour, probably of the same composition, is sometimes present on coffins of this period. It seems likely that this madder colour was introduced into Egypt by either the Greeks or the Romans, as the former probably knew it and the latter certainly did, since there are specimens of it in the Naples Museum.

Red

The principal red pigment of ancient Egypt, and the only one until a very late date, was red ochre, a natural oxide of iron that occurs

[1] Letter dated March 26th, 1892, from Mr. Spurrell to Professor Newberry who has kindly allowed me to make use of it.

[2] A. H. Layard, *Nineveh*, II (1854), p. 310.

[3] C. R. Williams, *op. cit.*, p. 25, *n.* 19.

[4] F. C. J. Spurrell, in *Medum*, p. 29.

[5] N. de G. Davies and A. H. Gardiner, *The Tomb of Amenemhet*, p. 98.

[6] N. and N. de G. Davies, *The Tomb of Menkheperrasonb, Amenmose and Another*, p. 25.

[7] S. R. K. Glanville, book review in *Journal of Egyptian Archaeology*, XIV (1928), p. 190.

[8] W. T. Russell, in *Medum*, p. 47.

plentifully in the country. This ochre is sometimes called hæmatite and, although it is an amorphous earthy variety of hæmatite, it would be better to restrict the term hæmatite in Egyptology to the black metallic-looking mineral employed for carving into beads, *ḳohl* sticks, scarabs and other small objects. Dioscorides says that the best red ochre was the Egyptian.[1]

Several red pigments of predynastic date identified as red ochre are known[2] and the reddish colours on the predynastic pottery are manifestly red ochre: Spurrell found red ochre (which he calls red hæmatite) and also red ochreous clays mixed with fibrous gypsum from the Fourth Dynasty[3] and red ochre (which he calls ground hæmatite) and burnt yellow ochre from both the Twelfth Dynasty and the Eighteenth Dynasty[4]; Russell found red ochre from the Twelfth and also from the Eighteenth or Nineteenth Dynasty[5] and I identified both red ochre and red ochre mixed with gypsum from the Sixth Dynasty; ten specimens of red ochre and one of red ochre mixed with gypsum from the Eighteenth Dynasty; one specimen of red ochre from the Nineteenth Dynasty and two from the period Twentieth to Twenty-sixth Dynasty. The Egyptian earths, *sinopis* and *rubrica*, referred to by Pliny as being employed by the Romans for pigment purposes,[6] were almost certainly red ochre. Vitruvius mentions red ochre from Egypt.[7]

The usual manner of making red ochre in Europe before the modern methods of manufacture from various by-products were introduced was by calcining yellow ochre, and though in any locality in Egypt in which yellow, but not red, ochre occurred the latter might have been made from the former by heating it, this was certainly not usual, the red ochre used being generally the material as found naturally, and what evidence Spurrell had for calling some of the red ochre he examined 'burnt yellow ochre' is not stated, and it is impossible as a rule to distinguish one from the other, especially when dealing with a very small quantity of pigment scraped from an ancient object. A good quality ochre of a deep-red shade is found in several localities in

[1] v: 112.

[2] J. E. Quibell and F. W. Green, *op. cit.*, p. 21; Sir R. Mond and O. H. Myers, *Cemeteries of Armant*, I, p. 131; G. Brunton, *Mostagedda*, p. 57.

[3] F. C. J. Spurrell, in *Medum*, pp. 28–9.

[4] F. C. J. Spurrell, in *The Arch. Journal*, LII, Second Series, II (1895), pp. 227, 231.

[5] W. T. Russell, in *Medum*, pp. 44–8.

[6] XXXV: 13–5.

[7] VII: 7, 2.

Egypt, of which two may be mentioned, one near Aswan,[1] where it was worked anciently, and the other in the oases of the western desert.[2, 3] A number of instances are recorded in Egypt in which yellow ochre on a tomb wall has been changed to red by the heat produced from a fire in the tomb.

A red pigment of Graeco-Roman date from Hawara was identified by Russell as red lead[4] (a red oxide of lead that occurs naturally), one of the few instances which has been reported from Egypt, though it was well known to the Romans of Pliny's day and probably was introduced by them into Egypt.

White

The use of white pigment for mural painting is known from the predynastic period,[5] but the nature of the material then employed, and also of that used on the predynastic pottery, has not been determined, though it must have been either calcium carbonate (whiting, chalk) or calcium sulphate (gypsum), as these were the only two white pigments known. Spurrell found gypsum from the Fourth Dynasty[6] and from the Eighteenth Dynasty,[7] but calcium carbonate from the Twelfth Dynasty at El Bersheh[8]: Russell found gypsum from the Graeco-Roman period at Hawara[4]: I identified calcium carbonate from the Fifth Dynasty; calcium sulphate from the Sixth Dynasty; twelve specimens of calcium carbonate and two of calcium sulphate from the Eighteenth Dynasty and calcium carbonate from the Twenty-third Dynasty. Both calcium carbonate and calcium sulphate occur plentifully in the country.

Yellow

Two different yellow pigments were employed by the ancient Egyptians, one being yellow ochre, which occurs plentifully in the country and the colouring matter of which is due to hydrated oxide

[1] L. Nassim, *Minerals of Economic Interest in the Deserts of Egypt*, in *Report of Congrès Intern. de Géog., Le Caire, Avril 1925*, III (1926), p. 164.
[2] W. F. Hume, *Explan. Notes to accompany Geol. Map of Egypt*, p. 38.
[3] H. J. L. Beadnell, *Dakhla Oasis*, pp. 99–100.
[4] W. T. Russell, in *Medum*, pp. 44–8.
[5] J. E. Quibell and F. W. Green, *op. cit.*, p. 21.
[6] F. C. J. Spurrell, in *Medum*, p. 28.
[7] F. C. J. Spurrell, in *The Arch. Journal*, LII, Second Series, II (1895), p. 232.
[8] Letter dated March 26th, 1892, from Mr. Spurrell to Professor Newberry, who has kindly allowed me to make use of it.

of iron, and the other being orpiment, a natural sulphide of arsenic. Yellow ochre was used in predynastic times[1]: Spurrell found yellow ochre from the Fourth,[2] Twelfth[3] and Eighteenth Dynasties[3] respectively and orpiment from the Eighteenth Dynasty[3]: Mackay refers to the use of orpiment in certain tombs in the Theban necropolis[4]: I found that three specimens of yellow pigment from the Eighteenth Dynasty were yellow ochre and eight were orpiment: one specimen from the Nineteenth Dynasty was ochre and two from the period Twentieth to Twenty-sixth Dynasty were also ochre: Russell reports yellow ochre from the Graeco-Roman period.[5] Petrie found a little orpiment in the town site of Gurob, probably of late Eighteenth or Nineteenth Dynasty date.[6] Yellow ochre occurs near Cairo[7] and in the oases of the western desert.[8]

At one time orpiment, originally the naturally occurring mineral and afterwards an artificial product, was largely employed as a pigment in Europe, but its use was discontinued on account of the very poisonous nature of the artificial substance. The natural mineral, however, is not poisonous and it was this that was used in ancient Egypt: in addition to its identification as a pigment on various objects and mural paintings a small quantity of the mineral in its natural state was found in a linen bag in the tomb of Tut-ankhamun and was examined by me.[9] As orpiment, so far as is known, does not occur in Egypt, it must have been imported and probably from Persia, though it also occurs in Armenia and in Asia Minor: its use in Egypt cannot be traced earlier than the Eighteenth Dynasty.

Paint Brushes

These have already been described in connexion with Fibres.[10]

Paint Vehicles

Much discussion has taken place respecting the nature of the paint

[1] J. E. Quibell and F. W. Green, *op. cit.*, p. 21.
[2] F. C. J. Spurrell, in *Medum*, p. 28.
[3] F. C. J. Spurrell, in *The Arch. Journal*, LII, Second Series, II (1895), pp. 227, 231–2.
[4] E. Mackay, *On the Use of Beeswax and Resin as Varnishes in Theban Tombs*, in *Ancient Egypt*, 1920, p. 37.
[5] W. T. Russell, in *Medum*, pp. 44–8.
[6] W. M. F. Petrie, *Kahun, Gurob and Hawara*, p. 38.
[7] L. Nassim, *op. cit.*, p. 165.
[8] W. F. Hume, *op. cit.*, p. 38.
[9] A. Lucas, *Appendix II*, p. 177, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter.
[10] See p. 160.

vehicles employed in ancient Egypt. The colours used, which have just been described, were ordinary well known materials, but in what state were they applied?

In modern painting practice there are two principal vehicles, one being a mixture of a fixed oil that dries (i.e. oxidizes) on exposure to the air (usually linseed oil, though formerly sometimes poppy seed oil or walnut oil) and a volatile oil (generally oil of turpentine, though recently sometimes a light petroleum spirit) and the other being a mixture of water and some adhesive, often size (gelatine or glue) or gum. Paints of the first kind are oil paints and those of the second kind are tempera paints (distempers).

It is manifest on examination that the ancient Egyptian paintings are not oil paintings, but tempera paintings.[1] Although linseed oil probably was known in Egypt from a very early date it was not used for painting until late, probably not until about the sixth century A.D. or after. Oil of turpentine, too, although certainly known in Pliny's day, since he describes a method of making the crude product,[2] and also probably to the Greeks at an earlier period,[3] was not employed for painting at that time and petroleum spirit is entirely a modern product.

The ancient Egyptian painting being tempera painting, it follows that some adhesive was used in its production, in the same manner as size and gum are employed to-day, since although pigments, such as soot and red and yellow ochres, will adhere to plaster and stone to some extent if applied dry, and although the ochres will adhere still better if wetted, others of the ancient pigments, such as azurite, malachite and the blue and green frits, will not adhere without some binding material. The possible and likely materials to have been used seem to be limited to size (gelatine, glue); gum and albumin (white of egg), which have already been discussed.[4]

One material used in Egypt for painting and for coating paintings, about which there is no uncertainty, is beeswax. Its use for mural paintings seems first to have been pointed out by Mackay,[5] who

[1] Excluding painting executed with a wax medium which will be described separately; see pp. 401–2.

[2] XV: 7.

[3] A. Lucas, *'Cedar'-Tree Products employed in Mummification*, in *Journal of Egyptian Archaeology*, XVII (1931), p. 16.

[4] See pp. 5, 8, 11.

[5] E. Mackay, *On the Use of Beeswax and Resin as Varnishes in Theban Tombs*, in *Ancient Egypt*, 1920, pp. 35–8.

mentions eight Eighteenth Dynasty tombs in the Theban necropolis in which there is evidence of wax, these ranging in date from the time of Amenophis I to that of Amenophis II. Although in some instances the wax is intimately mixed with the pigment, as though used as a binder, in other instances apparently it has been applied to the surface of the finished painting as a protective coating. Petrie mentions the use of wax[1] ' as a filling of the hieroglyphs on the red granite coffin of Ramessu III in the Louvre; also in incised figures on the wooden coffins.' He also states[1] that ' The use of wax over colours was noted on the late sarcophagus of Ankhrui at Hawara.' The use of wax in the Eighteenth Dynasty was also noticed by Spurrell, who found it at El Amarna,[2] and by de Garis Davies, who says with respect to the mural paintings in the tomb of Puyemrê, ' A film of wax seems present on many figures, but whether this was a medium used with the colours or was applied afterwards is not clear.' [3] I found one instance of the use of wax in the tomb of Tut-ankhamun, where there was a wooden box having an incised inscription filled with yellow pigment (orpiment) that was coated with beeswax, which had deteriorated, causing the pigment to appear almost white.[4] A similar use of beeswax, which had become ' whitish ' on a wooden coffin of late date has been pointed out by Carter.[5] The use of beeswax as a medium for painting was well known to the Romans and is described by Pliny,[6] who terms the method ' encaustic painting,' and about one hundred portraits in this technique of Roman age (second and third centuries A.D.) mostly on wood, but a few on canvas, used to place over the faces of mummies, were found by Petrie in the Fayum province of Egypt.[7] The method of encaustic painting used in Egypt has been described by Edgar,[8] and briefly by Lythgoe.[9] A bowl of late date, probably Coptic, with polychrome designs in the encaustic technique is described by Edgar, who states that ' The colours have been mixed with wax and put on with the brush.' [10]

[1] W. M. F. Petrie, note to Mackay's article, *Ancient Egypt*, p. 38.
[2] F. C. J. Spurrell, in *The Arch. Journal*, LII, Second Series, II (1895), p. 239.
[3] N. de G. Davies, *The Tomb of Puyemrê at Thebes*, I, p. 11.
[4] A. Lucas, in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, p. 180.
[5] Howard Carter, *Annales du Service*, II (1901), p. 144.
[6] XXXV: 31, 39, 41.
[7] W. M. F. Petrie, *Roman Portraits and Memphis (IV)*.
[8] C. C. Edgar, *Graeco-Roman Coffins, Masks and Portraits*, pp. xii, xiii.
[9] A. M. Lythgoe, *Bull. Met. Museum of Art, New York*, V (1910), pp. 67–72.
[10] C. C. Edgar, *Greek Vases*, No. 26347, p. 81.

Painting Grounds

The principal materials used in ancient Egypt for painting upon, taking them in alphabetical order, were canvas, papyrus, plaster, pottery, stone and wood. Of these, the earliest to be used was pottery, and this painted pottery will be dealt with separately.[1]

The next material in chronological order was plaster, of which several kinds were employed, namely, clay, gypsum and whiting (chalk). The earliest mural painting known in Egypt, which is of predynastic date, is executed directly on clay plaster[2] and this was also used as a painting ground at later periods, particularly in the Eighteenth Dynasty at El Amarna, where, both in the palaces of the king and also in private houses, the most beautiful painting was done directly on the clay plaster with which the walls of the sun-dried bricks were faced. The usual Egyptian plaster for painting upon, however, was either gypsum or whiting, the former being employed largely for mural paintings and the latter being used chiefly as a covering for wooden objects, such as coffins, boxes and stelæ, which subsequently were to be painted.

Gypsum plaster has already been considered[3]: a comparatively coarse quality was used for covering up faults and irregularities in the stone wall that was to be sculptured or painted or both and on this was laid a finer quality of similar plaster in order to obtain a smooth surface, this latter often being coated with whitewash to fill up the pores before painting.

Whiting plaster also has been briefly mentioned,[4] but may further be considered. By Egyptologists, this plaster, which is a mixture of whiting and glue, is generally called ' gesso,' but the term is ambiguous and is used sometimes for gypsum plaster or for gypsum and glue plaster. In mediæval Italy and Spain, gypsum mixed with glue water (size) was employed by artists to produce a ground for painting upon, which was termed *gesso*, an Italianized form of the Latin word *gypsum*, which is derived from the Greek *gypsos*. The term *gesso* in Italian, however, may mean any kind of gypsum or gypsum plaster. According to Cennino Cennini (fifteenth century)[5] gesso was of two kinds, *gesso grosso*, which was unslaked gypsum, and *gesso sottile*, which was slaked gypsum, both being used with glue. Theophilus,

[1] See p. 438.
[2] J. E. Quibell and F. W. Green, *op. cit.*, II, p. 21.
[3] See p. 96.
[4] See p. 95.
[5] A. P. Laurie, *The Materials of the Painter's Craft*, pp. 189–92.

writing about the eleventh or twelfth century,[1] refers to the use of both slaked lime and glue and whiting and glue for coating skins as a ground for painting upon and Church states[2] that 'The ordinary ground for Italian and Spanish tempera-paintings consisted either of whitening and size or of burnt gypsum . . . mixed with size.' This use of two different materials for the same purpose and the application of the same name to both is very confusing. Even *The New English Dictionary* gives the meaning of the Greek word *gypsos* as 'chalk, gypsum' as though these were synonymous, whereas they are two entirely different materials, and Church writes,[3] 'Gesso, made of plaster of Paris and size, or of whitening and size . . .' An outstanding example of painting on whiting plaster is the casket found in the tomb of Tut-ankhamun, which is a very ordinary wooden box coated on the outside with this plaster, on the surface of which, exquisitely painted in colours, are miniature battle and hunting scenes.[4]

Stone was often painted or colour-washed, not only the stone walls of tombs and temples, but also stone statues, statuettes, sarcophagi and other objects, especially, though not exclusively, those of limestone and sandstone, other stones, however, including granite, alabaster, quartzite and schist[5] also sometimes being painted. Before painting the scenes on the walls of tombs and temples a thin coat of whitewash was often, though not always, applied to the stone,[6] thus with respect to the painting of the walls of the temple of Medinet Habu, Nelson says, 'As the sandstone was too rough to take paint satisfactorily, a thin wash was applied to the stone before the colour was laid on.'[7]

The use of papyrus for painting upon is so well known that no description is necessary.

Canvas as a painting ground has been referred to already in connexion with the portraits of Roman date found by Petrie in the Fayum,[8] some few of which are on this material. Other examples of painted canvas are the so-called 'painted handkerchief' from Deir el Medineh,[9] a number of small painted cloths of Eighteenth Dynasty

[1] A. P. Laurie, *op. cit.*, pp. 157, 159–60.
[2] Sir A. H. Church, *The Chemistry of Paints and Painting*, 1915, pp. 22–3.
[3] Sir A. H. Church, *op. cit.*, p. 32.
[4] Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I, pp. 110, 111; Pls. XXI, L–LIV.
[5] G. A. Reisner, *Mycerinus*, p. 127.
[6] See p. 96.
[7] H. H. Nelson and Others, *Medinet Habu*, I, p. 7.
[8] See p. 402.
[9] Cairo Museum, No. J. 54885.

date that were found at Deir el Bahari[1] and the painted linen shrouds so well known from the Greek and Roman periods.

Wood usually was covered with plaster before being used as a painting-ground, though this was not always so, the paint sometimes being put directly on the wood, especially in the case of furniture and boxes, which often were painted in one colour only, usually red, white or brownish-yellow.

Since the greater number of the ancient Egyptian paintings are on the walls of tombs and temples and since fresco painting is a common form of mural decoration (as for example, the palace paintings at Knossos in Crete and those at Tiryns on the mainland opposite, the paintings at Herculaneum and Pompeii respectively and many of the mediæval wall paintings in Italy) the Egyptian mural paintings are often called frescoes, which are paintings executed on a damp surface made caustic with lime and without any other medium than water, which the Egyptian paintings never are. With respect to the painted pavement found by Petrie at El Amarna, the discoverer states[2] that ' the colours were laid on while the plaster was wet and even while it could still be moved by the brush,' which suggests a true fresco and which has been interpreted in that sense,[3] but fortunately I have been able to analyse a specimen of this plaster kindly supplied by Professor S. R. K. Glanville, which proved to be gypsum containing a large proportion of calcium carbonate (a very common impurity in Egyptian gypsum) and particles of unburnt fuel. Professor Laurie informed me that he found by practical experience that gypsum plaster, if painted upon before it was thoroughly dry, would show brush marks.

One interesting fact that may be mentioned in connexion with painting is that in some instances pigments have corroded the ground on which they were painted, thus Mr. and Mrs. de Garis Davies state that some of the colours ' eat away ' the plaster, leaving depressions,[4] and Mace and Winlock describe a painted canopic box where the pigment, probably blue, had corroded the wood in such a manner that what were originally painted inscriptions are now merely a series of holes in the wood, looking almost as though they had been

[1] E. Naville, *The XIth. Dynasty Temple at Deir el Bahari*, III, pp. 15, 16; Pls. XXX, XXXI.

[2] W. M. F. Petrie, *Tell el Amarna*, p. 12.

[3] S. R. K. Glanville, book review in *Journal of Egyptian Archaeology*, XIV (1928), pp. 189–90.

[4] Communicated verbally. See also N. M. Davies and A. H. Gardiner, *Ancient Egyptian Paintings*, III, 1936, p. xlvi.

burned.[1] This is attributed to the chemical composition of the pigment; but it seems much more likely that in all such cases the fault lies not with the pigment but with the vehicle which was either acid when used, or became acid subsequently, owing to chemical decomposition having taken place.

Varnish

The ancient Egyptian varnish is of two kinds, one originally colourless or practically colourless, though now brown, yellow or red and the other originally black and still black, both of which may now be described.

The colourless varnish was employed for covering mural paintings, wooden coffins, wooden canopic boxes, wooden stelæ, occasionally painted pottery and other objects.

The use of varnish in certain tombs in the Theban necropolis is mentioned by Mackay,[2] de Garis Davies,[3, 4] and Davies and Gardiner,[5] Mackay giving a list of ten late Eighteenth Dynasty tombs in which it has been used. In addition to its employment in the usual manner as a coating over the paintings, Mackay suggests that in some instances the pigment and varnish may have been mixed and applied together. Sometimes the varnish covers the whole surface of a wall, as for example in the tomb of Kenamun,[6] but more usually only certain colours, generally red and yellow, are varnished. This selective treatment also may be seen in the temple of Hatshepsut at Deir el Bahari.

As examples of the use of varnish other than for mural paintings may be mentioned (*a*) the wooden box with the painted miniature hunting and battle scenes from the tomb of Tut-ankhamun, which is covered with a thin uniform coat of varnish, originally colourless, but now yellow[7]; (*b*) various painted dummy wooden vases of the Eighteenth Dynasty, including two from the tomb of Yuya and

[1] A. C. Mace and H. E. Winlock, *The Tomb of Senebtisi at Lisht*, p. 32; Pl. VIII; and verbal statement by Mr. Mace.

[2] E. Mackay, *op. cit.*, pp. 36–7.

[3] N. de G. Davies, *The Tomb of Nefer-Hotep at Thebes*, I, pp. 12, 59, 63.

[4] N. de G. Davies, *The Tomb of Puyemrê at Thebes*, p. 11.

[5] N. de G. Davies and A. H. Gardiner, *The Tomb of Huy*, pp. 2, 7, 22.

[6] N. de G. Davies, (*a*) *The Tomb of Nakht at Thebes*, p. 57, *n.* 4; (*b*) *The Tomb of Ken-Amûn at Thebes*, I, p. 60.

[7] This box has now been treated with melted paraffin wax in order to preserve it.

Thuyu[1] and two painted red pottery vases of the same dynasty[2]; (*c*) especially the highly decorated wooden coffins and canopic boxes of the Twentieth Dynasty to about the Twenty-sixth Dynasty, which are usually varnished, the varnish often having been badly applied and put on thickly in some places and thinly in others; (*d*) a cylindrical 'kohlbox' found in the Roman-Nubian cemetery at Karanog, which is coated 'with a kind of gummy varnish, light brown in colour, which gave it a red lustrous appearance'[3] (apparently the coating was not tested, but 'gummy varnish' is a contradiction in terms and it seems probable that it was a resin varnish); (*e*) a small oval painted box of Roman date from the Fayum described by Wainwright,[4] who states that 'The whole has been given a coat of varnish, which has now turned black with age.' This is in the Cairo Museum and the coating was examined by me and was found to be soluble in alcohol and to exhibit all the characteristics of a resin varnish. A similar box of about the same date found by Petrie at Hawara is stated by him to be 'coated with glue.'[5] As the coating was scaling off Petrie treated it with paraffin wax in order to preserve it, which unfortunately prevents any simple chemical examination.

No certain use of a transparent varnish can be traced before the late Eighteenth Dynasty and only two instances of its use after the Twenty-sixth Dynasty, and it appears to have been almost unknown in both Ptolemaic and Roman times. Daressy, writing of certain painted wooden coffins, states[6] that the custom of varnishing them began in the Twentieth Dynasty and that it diminished and was lost a short time after the Twenty-second Dynasty.

There cannot be any doubt that this varnish, which is sometimes brown, though generally yellow where the coating is thin and orange-red where the coating is thick, was originally colourless, or practically so, since there are a number of instances where a white painted surface, which is partly varnished and partly unvarnished, is now yellow or red in the former case, but remains white in the latter case, and the edges of the varnished portions are so very irregular and unsightly that this cannot have been the original appearance and it

[1] J. E. Quibell, *The Tomb of Yuaa and Thuiu*, Nos. 51075 and 51083, pp. 45–6.
[2] Cairo Museum, Nos. J. 72517–72518.
[3] C. L. Woolley and D. Randall-MacIver, *Karanog*, III, 1910, pp. 71–2.
[4] G. A. Wainwright, *A Painted Box from Kom Washim*, in *Annales du Service*, XXV (1925), p. 97.
[5] W. M. F. Petrie, *Hawara, Biahmu and Arsinoe*, p. 12; Pl. XIX (25).
[6] G. Daressy, *Cercueils des cachettes royales*, Preface, p. iii.

can only be explained on the assumption that when the varnish was applied it was colourless and transparent and therefore it did not show, or, as aptly expressed by de Garis Davies,[1] 'The original transparency of the varnish is proved by the carelessness with which it was applied.'

Laurie states[2] that 'The reddish colour is very likely due to the introduction of a red like dragon's-blood,' but there is no evidence whatever that the red is original and a practical certainty that it is adventitious.

Only very few analyses of this varnish can be traced, namely, one by Laurie,[3] who states that his specimen (Nineteenth Dynasty) was soluble in alcohol and that it did not agree in its properties with pine resin, mastic or sandarach : one (undated) by Crow,[4] which was soluble in alcohol, and ether, but insoluble in turpentine and petroleum spirit, and a number by me (six Eighteenth Dynasty; one Twenty-first Dynasty; one of the period Twentieth Dynasty to Twenty-sixth Dynasty and several undated), which were all very similar in character and soluble in alcohol (both ethylic and amylic); slightly soluble in acetone and chloroform; insoluble or slightly soluble in ether and insoluble in turpentine, petroleum spirit and benzol. The ash in all cases was alkaline to phenolphthalein. The varnish is manifestly some kind of resin, but too little work has been done on the subject for any definite statement to be made respecting the nature of the resin, though as stated elsewhere,[5] the solubility and non-solubility in the various solvents, especially the insolubility in turpentine (in which most resins are soluble) are suggestive of shellac, which is a product of the lac insect, parasitic on certain trees that grow in Ceylon and farther India. That it is shellac, however, seems improbable, chiefly on account of the dark colour of natural shellac, whereas the Egyptian varnish was originally practically colourless and even now is never so dark as the shellac obtainable anciently, the modern methods of bleaching shellac being then unknown. It should not be forgotten, however, that the solubility of a material often decreases with age and exposure, for example that of colophony in petroleum spirit[6] and, therefore,

[1] N. de G. Davies, *The Tomb of Puyemrê at Thebes*, p. 11.
[2] A. P. Laurie, *The Materials of the Painter's Craft*, p. 31.
[3] A. P Laurie, *op. cit.*, pp. 27–31.
[4] J. K. Crow, *Report on Samples of Colours scraped from the Monuments*, in *Annales du Service*, IV (1903), pp. 242–3.
[5] A. Lucas, *Annales du Service*, IX (1908), p. 7.
[6] K. Dieterich, *The Analysis of Resins* (1920), pp. 161, 166.

insolubility in a particular solvent may be not an original, but an acquired characteristic.

Black Varnish

The black varnish was used on wood, possibly sometimes to simulate ebony or sometimes because a black colour was required for certain funerary objects. It is found, for example, on the wooden sarcophagi, the wooden canopic boxes and the food boxes of Yuya and Thuyu, on a number of objects from the tomb of Tut-ankhamun (two large wooden statues, numerous shrine-shaped boxes, the bases of three large couches, steering paddles for boats, certain human and animal figures and other objects), on a number of broken objects from the tomb of Horemheb (large statues, human and animal figures and parts of couches) and on certain late (probably Persian or Ptolemaic) coffins of cats and possibly of other animals. The varnish on one cat's (and cat-shaped) coffin in the Cairo Museum that has been examined by me is very glossy and similar in composition to the black varnish from the Eighteenth Dynasty.

So far as can be ascertained this black varnish was not employed before the late Eighteenth Dynasty, any black coating on wooden funerary objects of earlier date, for example, that on three sarcophagi from Qurna in the Cairo Museum dated to the Thirteenth or Fourteenth Dynasty (which has not been analysed, but which is mat and not glossy) is probably black paint and not varnish, and a black varnish-like coating on some copper funerary vases of Middle Kingdom date examined by me proved to be a nitrogenous adhesive, probably either glue or albumin (white of egg) coloured with carbon. As already mentioned this black varnish was in use as late as about Ptolemaic times.

Though often called bitumen or pitch, this varnish is neither, nor does it contain bitumen or pitch, but it consists of a comparatively low melting point resin, largely soluble in alcohol (from 51.6 to 90.5 per cent in the specimens tested) and acetone; insoluble or practically insoluble in turpentine, petroleum spirit, carbon disulphide, ether and benzol; soluble in pyridine and saponifiable with caustic soda. The specimens tested all gave off ammoniacal vapours when heated with quick lime, which indicates nitrogenous organic matter, but this may have been glue used as a sizeing material on the wood before varnishing.

Since the varnished objects were originally and intentionally black, the varnish cannot have blackened with age, as resins sometimes do, but must have been a naturally black resin. A few such resins are known, thus there is a black dammar resin from *Canarium strictum*, which grows in western and southern India and which would be a suitable material for making black varnish. Natural black varnishes that require no preparation are also known, such as the resin from *Rhus vernicifera* (Japan and China); the resin from *Melanorrhœa usitata* (Cochin-China and Cambodia); the resin from a species of *Melanorrhœa* (China) and the resin from *Melanorrhœa laccifera* (Indo-China), all of which are greyish-white viscous liquids when fresh and on exposure in thin films they dry to a hard black lustrous surface and are used as lacquers, and it seems probable that something of the kind may have been employed in Egypt.

Mode of Use

Before leaving the subject of varnish it becomes necessary to say something about the manner in which it was applied. The base of the old Egyptian varnishes, as of modern varnishes (excepting the very recent cellulose varnishes), is resin, but before resin can be applied as a thin coating it must be in a more or less liquid condition and the present day varnishes consist of a particular kind of resin dissolved in a 'drying' oil (generally linseed oil), turpentine or alcohol. Had a drying oil been employed anciently there would be abundant evidence, but there is no such evidence, and neither turpentine nor alcohol was known until a very late date; moreover the ancient varnish is insoluble in turpentine. Petrie suggests[1] that strong wine may have been used as a solvent, but I have tried to make a varnish from old Egyptian resins and also from modern varnish resins (mastic, sandarach and shellac) using sherry, the strongest white wine obtainable,[2] but without success, and the ancient varnish was found to be insoluble in sherry. The alternatives, therefore, seem to be, either a resin that did not require an extraneous solvent, or a resin soluble in a solvent such as the Egyptians might have possessed. The former means a naturally

[1] W. M. F. Petrie, *Medum*, p. 29.

[2] Sherry being what is termed a 'fortified' wine (i.e. one to which alcohol in addition to that naturally present has been added) is the strongest in alcohol of any wine, except port (which was too highly coloured for the experiments), and almost certainly stronger than any of the old Egyptian wines.

occurring resin already liquid. Such resins, which are termed oleo-resins, are plentiful (pine and larch resins are of this class), the solvent being a volatile oil (oil of turpentine) that gradually evaporates on exposure. The only solvent that can be suggested that the ancient Egyptians might have used is a solution of natron in water and the only resin soluble in alkaline water solutions that is known to me is shellac, from which an excellent varnish may be made by dissolving it in a solution of borax or ammonia in water, both of which materials, however, were probably unknown in ancient Egypt, though natron was well known and its possible use will be discussed later.

The oleo-resins, though nominally liquid, are at best of a thick syrupy consistency, which, however, may be reduced by warming. A natural oleo-resin applied warm, therefore, seems a possible explanation, and Laurie accepts this as being likely and states that 'As such volatile mediums as alcohol, turpentine and petroleum spirit were almost certainly unknown in ancient Egypt, we are driven to conclude that this varnish was a natural semi-liquid resin as obtained from the tree . . . probably laid on after warming.'[1] According to Davies a scene in an Eighteenth Dynasty tomb at Thebes representing coffin-making shows 'resinous varnish being heated and stirred in a great pan set on a fire.'[2] Another suggestion that has been made is that the resin was applied in a finely powdered condition and was then liquified and spread by means of heat,[3] but this does not appear feasible, and, in the case of a vertical surface, like a tomb wall, the resin would have had to be made to adhere first before it could have been spread. Laurie explains, too, that 'A solid resin, if fused by heat, cannot be spread on a surface properly and at once cracks on cooling,'[4] and for this reason Mackay thinks[5] that the varnish on tomb walls must have been melted on, because certain of the varnished surfaces are cracked.

I have made a large number of experiments with a typical oleo-resin as obtained from the tree, namely Venice turpentine[6] (larch turpentine; the oleo-resinous exudation of *Larix Europæa* or *Larix decidua*), which at 20° C. (68° F.) was a viscous liquid, like thick syrup. Even in this condition it was found possible to apply it to wood

[1] A. P. Laurie, *The Materials of the Painter's Craft*, pp. 30–1.
[2] N. de G. Davies, *The Tomb of Nefer-Hotep at Thebes*, I, pp. 45–6; Pl. XXVII.
[3] R. S. Morrell, *Varnishes and their Compounds*, p. 2.
[4] A. P. Laurie, *ibid.*
[5] E. Mackay, *op. cit.*, p. 37.
[6] A specimen guaranteed pure was kindly supplied by Messrs. The British Drug Houses Limited, London.

(previously well sized with glue size) by means of a stiff bristle brush. The layer, however, though fairly thin, was not at first of uniform thickness and was covered with brush marks, but on standing a very short time the brush marks disappeared entirely and the layer became uniform. At temperatures of 30° C. (86° F.) and 35° C. (95° F.) the material, though less viscous, was still syrupy, but at 60° C. (140° F.) it became much thinner and could be taken up readily on a brush and applied to the wood, but the material cooled so quickly that, before it could be brushed on as a thin uniform coating, it became syrupy and much in the same state as at 20° C. (68° F.) and similarly was covered with brush marks and, except for the ease of filling the brush, there was practically no advantage in using it at the higher temperature. One great disadvantage of the particular oleo-resin tried, and therefore presumably of all oleo-resins, is the very slow drying. In the experiments made (the temperature of the room being about 15° C. to 20° C. (59° F. to 68° F.) during the day and lower at night) the 'varnish' took about five days before it was anything like dry, and even then it was a little tacky and remained so for about seven weeks, when it was completely dry.

Experiments also were made with shellac (both button lac and garnet lac of the best qualities obtainable) and a solution of natron, using various proportions of shellac and various strengths of natron. The solution that appeared to give the best results, so far as the experiments were carried, was 16 per cent of natron (containing 7 per cent of sodium chloride and 3 per cent of sodium sulphate) and 20 per cent of shellac, which were boiled together for about ten minutes. This, while hot, could be brushed on to the wood (previously well sized with glue size), but, owing to the shellac becoming quickly insoluble (or largely insoluble) on cooling, the coating was not continuous, but patchy and fairly thick. This coating soon became hard, but it did not possess the glossy appearance of varnish, and both the solution and the applied coating were of a dark reddish-violet colour, totally unlike the colour of the ancient varnish. It seems quite probable that as a result of further experiments with other strengths of natron and shellac, and possibly also different ways of effecting the solution, a fairly thin coating might be obtained, but the experiments were discontinued since any coating obtainable would still have had the dark colour of the shellac that makes it impossible that this could have been the ancient varnish. Any artificial bleaching of the shellac at the early date when the varnish was used appears highly improbable.

The summary of the matter is that a coniferous oleo-resin, although it gives a fairly satisfactory varnish-like coating of a light brownish-yellow colour that resembles the ancient varnish in being soluble in alcohol, seems excluded because all these oleo-resins are soluble in spirits of turpentine, whereas the ancient varnish is insoluble, and shellac also seems to be excluded because, although readily soluble in alcohol and insoluble in turpentine, and so resembling the ancient varnish in these respects, the colour is much too dark. No other resins having the characteristics of the ancient varnish that could be dissolved in any solvent known to the ancient Egyptians can be suggested, though possibly some resin (not a coniferous one) may ultimately be found that is sufficiently liquid to be applied with a stiff brush and that is insoluble in turpentine. As any such resin is likely to have been a product of western Asia and to have been used there for varnish before it became known in Egypt, the early history of the use of varnish in Persia might throw some light on the problem.

That such a useful material as varnish should have practically disappeared without leaving any substitute, as the Egyptian varnish did during the Ptolemaic and Roman periods,[1] is unusual, a possible explanation being that the source of supply of the resin was cut off, for example by wars in Asia.

Writing Materials

For the purposes of description the ancient Egyptian writing materials may be divided into two main classes, namely, those that were essential and those that were accessory. The primary materials comprised the ink, the ground on which the ink was placed in the act of writing and the implements (pens) used to transfer the ink to the ground destined to receive it. The secondary materials included the grinders used by the scribes to prepare the ink and the receptacles on, or in, which the ink and pens were kept when not in use. All these objects may now be described.

Pigments

The ink was in the form of small cakes of solid material, resembling, except in shape, modern water-colours and was generally of two kinds, red and black, though occasionally additional colours occur on a palette,

[1] One instance only of the late use of varnish is known; see p. 407.

these, however, being employed by the artist for illustrated scenes and not by the scribe in writing. One such palette, bearing the name of Mert-Aten, was found in the tomb of Tut-ankhamun,[1] on which there had been originally six colours, only five, however (black, green, red, white and yellow) now remaining, one (almost certainly blue) being missing.

The cakes of colours probably were made by mixing finely ground pigment with gum and water and drying, and they were used in the same manner as modern water-colours, namely, by dipping the pen in water and rubbing it on the ink.

Garstang reports carbon and red ochre respectively for the black and red colours on a palette of Middle Kingdom date.[2]

Laurie found the colours on an Egyptian palette dating from about 400 B.C. to consist respectively of charcoal, red ochre, gypsum, blue frit and yellow oxide of lead.[3]

Hayes found ' sections of thick reed containing carbon used in the manufacture of ink ' of Eighteenth Dynasty date at Thebes.[4]

Barthoux examined the pigments from certain Egyptian palettes, which unfortunately were undated,[5] though judging from the results, some were of a very late period. The white was calcium carbonate in some instances and magnesium carbonate in others; some of the red was red ochre and some red lead (minium); the brown was limonite (one form of oxide of iron); the yellow was yellow ochre containing in some instances calcium sulphate; the green is reported as powdered glass and the blue was a frit. As the use of minium in Egypt is very unlikely before Roman times, this specimen was probably of very late date. The calcium sulphate found with the yellow ochre was probably a naturally occurring impurity and the green described as glass was probably the well known artificial green frit. The black was carbon.

I have examined nine specimens of pigments from palettes, one white, of Old Kingdom date, which proved to be calcium carbonate and eight of the Eighteenth Dynasty; one white, which was calcium sulphate, one bright yellow, which was orpiment (sulphide of arsenic);

[1] Howard Carter, *The Tomb of Tut-ankh-Amen*, III; Pl. XXIII (A).

[2] J. Garstang, *The Burial Customs of Ancient Egypt*, p. 77.

[3] A. P. Laurie, *Ancient Pigments and their Identification in Works of Art*, in *Archaeologia*, LXIV (1913), pp. 318–9.

[4] W. C. Hayes, *Bull. Met. Museum of Art, New York, Egyptian Exped. 1934–1935*, p. 34.

[5] J. Barthoux, *Les fards, pommades et couleurs dans l'antiquité*, in *Congrès internat. de Géog., Le Caire, Avril, 1925*, IV (1926), pp. 257–8.

three red, all of which were red ochre; and three black, which were carbon.

Of the ink on documents, only one published analysis can be traced, which is by Wiesner, given in his account of the Rainer papyri from the Fayum,[1] which date from the ninth to the thirteenth century A.D. Wiesner states that the papyri are written with two different kinds of ink, one a carbon ink and the other an iron ink. Schubart also mentions two kinds of ink on papyrus,[2] one black and one brown, the latter dating from the fourth century A.D., but the nature of this ink, the brown colour of which suggests an iron ink, apparently was not determined.

Specimens of black ink on Coptic ostraca were found by Crum to consist essentially of carbon.[3]

Various specimens of black ink on documents have been examined by me.[4] These included a number on ostraca (undated); a number on papyri, ranging in date from Roman times to the ninth century A.D., all of which were carbon, and a number on parchment documents dating from the seventh to the twelfth century A.D., in all of which cases the ink was an iron compound.

The carbon used for making ink was soot in most cases, probably generally scraped from cooking vessels, though occasionally specially prepared, the charcoal found by Laurie being exceptional. One method of making carbon for ink to be used for writing religious books, which was kindly supplied to me by a priest of the Coptic Church, is as follows: Put a quantity of incense on the ground and round it place three stones or bricks, and, resting on these, an earthenware dish bottom upwards, covered with a damp cloth; ignite the incense. The carbon formed is deposited on the dish, from which it is removed and made into ink by mixing with gum arabic and water. An old Arabic book in the Royal Library at Cairo (unfortunately anonymous and undated) contains a recipe for making what is called Persian ink. The method is to take date stones, put them in an earthenware vessel stoppered with clay and put the vessel over a fire until the next day, then remove the vessel, allow it to cool, grind and sift the contents and make into ink with gum arabic and water. An ink such as this last, however, would be of poor quality and would contain very little free carbon.

[1] J. Wiesner, *Mittheilungen aus der Sammlung der Papyrus Erzherzog Rainer*, 1887, pp. ii–iii, 239, 240.

[2] W. Schubart, *Einführung in die Papyruskunde*, 1918, p. 44.

[3] W. E. Crum, *Coptic Ostraca*, p. x, *n.*

[4] A. Lucas, *The Inks of Ancient and Modern Egypt*, in *Analyst*, 1922, pp. 9–14

Carbon is the oldest ink material known and in Egypt its use for writing can be dated back to a period before the beginning of the First Dynasty, that is before about 3400 B.C., Petrie having found 'dozens of pottery jars with ink inscriptions' of a date 'probably half-way back in the dynasty before Mena.'[1] From the First Dynasty there are also examples of black ink writing, some on pieces of broken stone bowls[2]; one on a jar-sealing[2] and two on wooden tablets.[3, 4] It is true that in none of these instances has the ink been analysed, but that it should be anything other than carbon is most unlikely.

Writing Grounds

The materials on which the ancient Egyptian writing was executed were very varied, and, taking them in alphabetical order, included bone (the shoulder blade of a camel with a Coptic inscription in ink is in the Cairo Museum); clay (several tablets of dried clay of Eleventh Dynasty date, some with incised inscriptions and some with ink inscriptions are in the Cairo Museum and, as the El Amarna letters show, baked clay tablets were used for official correspondence between Egypt and western Asia in the Eighteenth Dynasty, the writing on these latter being in incised cuneiform characters in the Babylonian language); ivory; leather (some Egyptian manuscripts on leather are in the British Museum[5, 6] and one of Sixth Dynasty date unrolled by Dr. Ibscher is in the Cairo Museum); linen; metal (one specimen of 'bronze' and one of lead, both bearing writing in incised characters and both of Roman age are in the Cairo Museum); papyrus; parchment and vellum (the former being made from the skins of sheep and goats and the latter from the more delicate skins of calves and kids and neither having been employed before a very late period); pottery; reed (a large split reed with a Coptic inscription written in ink on the inside is in the Cairo Museum); stone (chiefly small flat pieces of limestone); wax (beeswax in the form of a thin uniform coating, usually coloured black, spread on wooden tablets, the writing being

[1] W. M. F. Petrie, *Abydos*, I, p. 3.
[2] W. M. F. Petrie, *The Royal Tombs*, I, pp. 15, 21.
[3] W. M. F. Petrie, *The Royal Tombs*, II, p. 38.
[4] J. E. Quibell, *Excavations at Saqqara (1912–1914)*, p. 6.
[5] S. R. K. Glanville, *The Mathematical Leather Roll in the British Museum*, in *Journal of Egyptian Archaeology*, XIII (1927), p. 232.
[6] *Infra-Red Photographs of Illegible Leather Manuscripts*, in *The British Museum Quarterly*, VIII (1933), pp. 52–3.

incised in the wax by means of a pointed implement called a stilus which was not used before Graeco-Roman times) and wood (both plain and coated with a thin coating of plaster). The most important writing material, however, was papyrus, which has already been dealt with in connexion with Fibres,[1] but cheaper substitutes were used for unimportant and ephemeral purposes, the principal of which were fragments of broken pottery and fragments of limestone, to both of which the name of ostraca has been given.

Pens

From a very early period until about the third century B.C., an interval of several thousand years, the ancient Egyptian writing implement, as proved by numerous specimens that have been preserved, was a particular kind of rush (not reed, as generally stated), *Juncus maritimus*, that grows plentifully in Egypt at the present day (generally in salt marshes). Portions of the required length of this were taken and one end, as shown experimentally by Dr. H. Ibscher, who kindly demonstrated it to me, was cut to a flat chisel-shape. With the flat side the thicker lines were made and, with the fine edge, the thinner lines. Eleven specimens from the Eighteenth Dynasty measured by me varied from 6.3 inches (16 cm.) to nine inches (23 cm.) in length and were all approximately one-sixteenth of an inch (1.5 mm.) in diameter. A bunch from the Twelfth Dynasty measured by Quibell were all sixteen inches long and one-tenth of an inch in diameter.[2] From the Graeco-Roman period onwards the rush pen was superseded by a piece of reed, *Phragmites communis*, cut to a point and split in the same manner as the quill pen formerly employed in Europe. This reed, which was used by both the Greeks and Romans 'from the 3rd century B.C. onwards'[3] was doubtless the Egyptian reed mentioned by Pliny (first century A.D.) as being employed for writing.[4] Petrie illustrates a number of these pens of Roman date found by him in Egypt.[5] Winlock says[3] that 'The complete adoption of the split pen by the Egyptians may be safely related to the adoption of the Greek alphabet for writing the Egyptian language during the 4th century A.D.' The monks of the Christian Monastery of Epiphanius at Thebes in the sixth or seventh century A.D. were using split pens. 'The pens

[1] See p. 162. [2] J. E. Quibell, *The Ramesseum*, p. 3.
[3] H. E. Winlock and W. E. Crum, *op. cit.*, pp. 93–4.
[4] XVI: 64.
[5] W. M. F. Petrie, *Objects of Daily Use*, Pl. LVIII (54, 55, 56, 58).

were made of reeds, which averaged about 1 cm. in diameter. An unused new pen . . . was 26.5 cm. long. The old pens had been resharpened so often that finally they were mere stumps less than 6 cm. long . . . and one of them had been lengthened by sticking a bit of wood into the end.'[1] Pens of this kind are still being employed in Egypt at the present day, though their use is gradually dying out.

Grinders

The grinders employed by the scribes to prepare their 'ink' were usually small rectangular pieces of stone, having a slight depression in the middle of the top and a raised edge all round[2] with a small pestle or muller (often cone-shaped) of similar stone,[2] or occasionally instead of the pestle, a small stone spatula.

Palettes

The palettes, which were made of various materials, were rectangular in shape and provided with depressions (usually circular, but sometimes rectangular) for the cakes of ink and a recess for holding the 'pens.'[3] The materials included ivory (two examples of which were found in the tomb of Tut-ankhamun[4]); wood; wood covered with gold (an example was in the tomb of Tut-ankhamun[4]) and stone, often alabaster, sandstone, 'schist,' or serpentine.

In the tomb of Tut-ankhamun, in addition to the normal palettes there were twelve others that were purely funerary,[5] having imitation cakes of pigment, some of stone and some of glass, and imitation pens of glass.

Sometimes separate receptacles were provided for the ink[2] and the pens, and two of the latter are in the Cairo Museum, one very ornate being from the tomb of Tut-ankhamun[4] and another, similar in shape though not so highly ornamented, having been found by Howard Carter many years before.[6]

[1] H. E. Winlock and W. E. Crum, *op. cit.*, pp. 93-4.
[2] W. M. F. Petrie, *Objects of Daily Use*, Pl. LVI.
[3] *Id.*, Pl. LVII.
[4] Howard Carter, *The Tomb of Tut-ankh-Amen*, III, Pl. XXII.
[5] Howard Carter, *op. cit.*, p. 79.
[6] The Earl of Carnarvon and Howard Carter, *Five Years' Explorations at Thebes*, Pl. LXVI.

Marking Ink

In connexion with ink, it may be mentioned that the Egyptians frequently had their linen garments marked with their names in 'ink,' one specimen of which was analysed by Dr. Ainsworth Mitchell and proved to be an organic material, free from carbon, that was not identified.[1] Other specimens of marking ink, also examined by Mitchell, were from a Second Dynasty tomb at Saqqara and proved to be iron oxide.[2]

[1] C. A. Mitchell, *Alleged Use of Marking Ink in Ancient Egypt*, in *The Analyst*, 1927, p. 18.

[2] C. A. Mitchell, An Ancient Egyptian Marking Ink, *The Analyst*, 65 (1940), pp. 100–1. See also H. E. Winlock, Materials used at the Embalming of King Tut-ankh-Amun, *Paper No. 10, Met. Museum of Art, New York*, 1941.

CHAPTER XV

POTTERY

By pottery is meant ware made from clay, moulded into shape while wet and then hardened by being baked, faience, which has already been dealt with, not being pottery.

Clay

Clay is a colloidal, plastic material of secondary origin, derived from the disintegration and decomposition of certain kinds of primary rocks. The essential constituent of all clays is hydrated aluminium silicate, but with this are mixed variable, though usually small, proportions of natural impurities, chiefly alkalies (combined, not free), iron compounds (to which the colour is largely due), calcium carbonate, organic matter (humus), quartz sand and water, and it is the kind and amount of impurities present that condition the nature of the clay.

The water contained in clay is in two forms, one mechanically mixed, and it is on this that the plasticity depends, and the other chemically combined, and when clay is dried, the former, or interstitial water, is driven off and the material temporarily loses its softness and plasticity and becomes hard and friable, but if wetted it will take up water and become plastic again; when clay is more strongly heated or baked, the chemically combined water is also driven off and the material then becomes very hard and entirely loses its capacity for being acted upon by water and if wetted it does not revert to its former plastic condition.

The Egyptian clay employed for pottery making is essentially of two kinds, one of a brown or blackish colour when wet, but a brownish-grey when dry, which contains a comparatively large proportion of organic matter and iron compounds, together with varying amounts of sand, and this kind becomes brown or red when heated, and the other of a brownish-grey colour when wet, but grey when dry, which contains very little organic matter, but a comparatively large proportion of calcium carbonate, and this, which is a calcareous clay

or marl, burns to a grey colour. The former occurs throughout the Delta and the Nile valley, whereas the latter is found only in a few localities, of which Qena and Ballas[1] in Upper Egypt are the most important.

Pottery making is one of the oldest of the arts and in Egypt dates back to neolithic times. At first the pots were of coarse material, crude workmanship, devoid of finish and badly baked, but by the Badarian and the succeeding predynastic periods the Egyptian potter was producing wares that for beauty of form and finish were extraordinarily good.

In the making of a pottery vessel there are four main stages, namely, kneading the clay; shaping the clay into a pot; drying the pot and finally baking it, all of which may now be considered.

Kneading

Before clay is fashioned into pots any small stones or other foreign material are usually first picked out and the clay then brought to a uniform and right consistency, which is done in Egypt at the present day, and, therefore, doubtless also anciently,[2] by thoroughly kneading it with water by means of the feet, with sometimes the addition, when the clay is too 'rich' or too 'fat,' of organic matter in the form of finely chopped straw, fine chaff or powdered animal dung. These are used in order to reduce the stickiness (which makes it difficult to manipulate), to assist the escape of water during drying and to prevent undue shrinkage with its accompanying cracking and distortion during drying, also to strengthen 'poor,' 'lean' or sandy clay. This 'tempering' of the clay is not merely a modern device, but it was employed anciently, as is proved by the fact that it is not unusual to find in predynastic and early dynastic pottery either chopped straw or evidence that this had been used and had burned out during baking.[3]

Shaping

In the early days of pottery making in Egypt, that is during neolithic and predynastic times, pots were made by hand, and Petrie

[1] An analysis of the Ballas clay will be found on p. 550.

[2] This is almost certainly shown in a Twelfth Dynasty tomb at Beni Hasan. (P. E. Newberry, *Beni Hasan*, 1; Pl. XI).

[3] J. E. Quibell, *Archaic Objects*, pp. 137–77.

states[1] that 'The first use of the wheel regularly is for the great jars of the royal factory in the 1st Dynasty': Reisner says[2] that the beginning of wheel-made pottery dates from the reign of Khasekhemui and the accession of Sneferu and Frankfort states[3] that the potter's wheel was only generally used in Egypt 'about the Fourth Dynasty, though sporadically appearing since the First.' This wheel in its early and simple form was merely a small circular platform, rotated slowly by hand on a vertical pivot or shaft, on which the clay was placed while being shaped. Its nature and mode of use are depicted on the wall of a Fifth Dynasty tomb at Saqqara[4] and on the walls of Twelfth Dynasty tombs at Beni Hasan[5] and at El Bersheh.[6] Wheel-made pottery, however, has never entirely displaced the hand-made variety in Egypt, the latter being still made to some extent at the present day.[7]

The final stage in the shaping of a pot is usually to smooth the surface with the wet hand, which not only improves the appearance but also makes the pot less permeable to liquids by filling up the pores with fine particles of clay. This, as pointed out by Peat, 'often gives the impression that a separate slip of finer clay has been applied when this is not really the case.'[8]

Slip

A slip on pottery consists of finely levigated, light-coloured, non-red-burning clay mixed with water to the consistency of cream and applied before the pot is dried. It has four functions, primarily, if applied to a red-burning clay, it changes the colour of the pot to drab or buff, a colour that at certain periods was more fashionable, or that may have been thought to be more agreeable than red, but a slip also makes the pot less permeable to liquids, lends additional smoothness to the surface and makes an admirable ground for painting.

Drying

After the pot is made it is wet, sticky and useless until it has been dried, which must be done before baking, otherwise the rapid

[1] W. M. F. Petrie, *Descriptive Sociology, Ancient Egyptians*, p. 57.
[2] G. A. Reisner, *A Provincial Cemetery of the Pyramid Age, Naga-ed-Dêr*, III, p. 185.
[3] H. Frankfort, *Studies in the Early Pottery of the Near East*, I, p. 107, *n.* 5.
[4] G. Steindorff, *Das Grab des Ti*, Pls. 83, 84.
[5] P. E. Newberry, *Beni Hasan*, I, Pl. XI; II, Pl. VII.
[6] P. E. Newberry, *El Bersheh*, I, Pl. XXV.
[7] W. S. Blackman, *The Fellāhīn of Upper Egypt*, pp. 136–7.
[8] T. E. Peet, *The Cemeteries of Abydos*, II, p. 12.

vaporization and escape of the mechanically-held water that would take place in the fire or kiln would rupture the pot.

Polishing

The only period during which a clay pot can be polished by simple rubbing with a pebble or other hard smooth object is when the clay is almost but not quite dry. This is a phenomenon depending upon the physical nature of clay, which is a material that it is impossible to polish by simple rubbing when wet or when quite dry (as just before baking) or after being hardened by baking, and it is only by the use of certain materials such as oil, fat, wax or graphite (blacklead) that it is possible to polish dry or baked clay. The polish produced by rubbing varies with the nature of the clay, being more brilliant on a 'rich,' 'fat,' or well levigated clay than on a poor, calcareous or coarse one.

When an unbaked clay vessel, either with or without a wash of red ochre, is pebble-polished and then baked, the colour is so altered, first by the polishing and then by the baking, that often it seems hardly to be the same vessel, which facts need to be taken into account before deciding whether or not a vessel has been treated with a slip or wash. Peet says[1] 'In a polished vase the fact that the surface is darker than the fracture does not prove the presence of a slip, for the very process of polishing almost always darkens the surface colour.'

The polish applied to clays before baking not only persists after baking and blackening, but often is more brilliant on the final black than it was on the original red, probably purely an optical effect due to the different manner in which the two colours reflect the light. Petrie states[2] that 'The reason of the polish being smoother on the black than on the red parts is that carbonyl gas—which is the result of imperfect combustion—is a solvent of magnetic oxide of iron and so dissolves and re-composes the surface facing.' In another place[3] Petrie says 'This is probably due to the formation of carbonyl gas in the smothered fire; this gas acts as a solvent of magnetic oxide, and hence allows it to assume a new surface, like the glossy surface of some marbles subjected to solution in water.' There is, however, no evidence for any such reaction, which is most improbable. Forsdyke says[4] 'The

[1] T. E. Peet, *The Cemeteries of Abydos*, II, p. 10, *n.* 2.
[2] W. M. F. Petrie, *Arts and Crafts of Ancient Egypt*, 1910, p. 130.
[3] W. M. F. Petrie, *Diospolis Parva*, p. 13.
[4] E. J. Forsdyke, The Pottery called Minyan Ware, *Journ. of Hellenic Studies*, XXXIV (1914), p. 141.

difference between the reflecting powers of black and red surfaces need hardly be remarked; but it is well illustrated in the well-known predynastic Egyptian vases which are bright red with a black band at the lip. The polish is certainly stronger on the black part, but it extends all over the surface and is hardly visible on the red colour.'

With certain ancient red-polished sherds that were blackened by making them red-hot and then burying them in sawdust, the polish not only became more brilliant, but acquired the metallic sheen seen on much of the black of the Badarian and predynastic black-topped ware, which is very like a graphite polish in appearance, which of course it cannot have been on the treated sherds and which it probably is not on the Badarian and predynastic pottery. A graphite polish, however, was found by Reisner[1] on some of the ware from the Middle Kingdom Egyptian colony at Kerma in the Sudan, and graphite is used to-day in certain districts of the Sudan for giving a polish to a surface already black,[2] but there is not any evidence for its use in Egypt. Polishing makes pottery impermeable to liquids.

Baking

Finally, the pot is baked in order to drive off the chemically-combined water, the loss of which is necessary to convert the clay from its original weak, friable state, in which it is softened by water, into a hard, durable, stone-like mass, unacted upon by water. This reaction takes place between 500° C. (937° F.) and 600° C. (1,112° F.), the combined water (13–14 per cent) being rapidly given off at ordinary atmospheric pressure as the temperature rises beyond 500° C.[3]

As for the manner of baking, there can be little doubt that at first the dried pots were baked on the ground as a mixed heap of pots and fuel, probably covered over with animal dung to conserve the heat, as is done to-day in the Sudan and by primitive people elsewhere. The fuel available was principally straw, chaff, animal dung, reeds, rushes and sedges. At a later date, the heap might have been surrounded by a low wall of clay and the dung covering replaced by clay and finally a simple kiln with a separation between the pots and the fuel would be evolved. As a pottery kiln is shown in a Fifth Dynasty tomb at

[1] G. A. Reisner, *Excavations at Kerma*, IV–V, p. 329.
[2] J. W. Crowfoot, *op. cit.*, pp. 133–4.
[3] J. W. Mellor, *Inorganic and Theoretical Chemistry*, VI, p. 482.

Saqqara,[1] its use must have been well established at that date: pottery kilns are also depicted in Twelfth Dynasty tombs at Beni Hasan[2] and in an Eighteenth Dynasty tomb at Thebes.[3]

Colour

An important feature of pottery is its colour, which may now be considered.

The colour of pottery, apart from any slip, wash or paint, depends upon several factors, the principal of which are the kind of clay used and the nature of the firing.

Even a mere enumeration of the different colours of pottery is not without difficulty, partly on account of the large variety of shades or gradations of colour that occur and partly because some of the colours are usually described by terms such as 'drab' and 'buff' that lack precision of meaning and, therefore, are not always employed in the same sense. The colours of the plain, unpainted and undecorat pottery that will specially be discussed are brown, black, red, black and partly red, and grey, and the nature and cause colours will now be considered.

Brown Ware

A brown colour in pottery is generally that of the clay has not been modified, or only slightly modified (apa lightening of the colour due to drying), by the very imper the black patches often present being smoke stains and therefore, the fire must have been a poor and smoky one. T although usually confined to the most primitive pottery, m almost any period. The Egyptian neolithic pottery and so Tasian pottery are of this kind.

Black Ware

Black pots probably were first produced occasionally but accident cannot account for a continuous produ ware, which arose doubtless from a deliberate attem

[1] G. Steindorff, *Das Grab des Ti*, Pl. 84. In plat scenes described as '*Brennen von Töpfen*' depict th with bread baking and not the burning of pot

[2] P. E. Newberry, *Beni Hasan*, I, Pl. XI; I

[3] N. de G. Davies, *The Tomb of Ken-A*

inevitable and disfiguring smoke stains of the earliest pottery by utilizing a smoky fire, such as caused them, to make the pots wholly black, or as so well expressed by Myres,[1] 'what had begun as an accidental disfigurement had been seized and utilized . . . and developed into an intentional technique.' It would soon be realized, however, that a fire continuously smoky was not satisfactory for the production of well-baked pottery and that the best way of obtaining pots that were both hard and black was to bake them first in a fire as hot as could be obtained and to blacken them after the baking by exposing them to dense smoke.

Black pottery is not at all uncommon in Egypt at the present day and it is made in a very simple manner. Ordinary red or reddish pottery is first made in the usual way and at the end of the baking, when the flames of the fuel have died down, but while the pots are still red-hot, the furnace door is opened and some smoke-producing combustible (in one factory it was pitch and in another a mixture of coal and pitch) is thrown on to the hot ashes. This, which does not come into contact with the pottery, produces dense smoke, which blackens the pots. The ware, although generally described as black, is really not very dark grey, not only on both surfaces, but through with, however, sometimes a suspicion of brown just ce.

d other writers[3] describe primitive modern processes k pottery in which the pots direct from the fire and buried in and covered with organic material, such as . leaves, which in contact with the hot pots smoulders ense smoke that in a very short time blackens the pots, the surface, but throughout if the vessels are thin, or bstance of the ware when the vessels are thick.

uced black pottery on a small scale in the laboratory in ner by heating ancient red ware (fragments), modern niature pots) and modern grey ware (fragments and s) in an electric furnace until red-hot and then immediately n in sawdust, chopped straw or chaff and allowing them rious periods of time varying from a few minutes to

Pot Fabrics of Asia Minor, in *Journ. Royal Anthrop.*

on Pottery, in *Sudan Notes and Records*, VIII

about half an hour. The sawdust, chopped straw or chaff, becoming carbonized, produced dense smoke, which not only blackened the surface of the pottery, but definitely penetrated below the surface, and when the pottery was broken it was seen to be black at both sides with a grey zone in the centre. In other experiments pieces of modern grey ware (cold) were suspended by wire inside and near the top of a metal cylinder, which was closed except for the two small holes in the top through which the wire passed. At the bottom of the cylinder a deep layer of sawdust, chopped straw or chaff was placed and heat was applied to the outside of the bottom of the cylinder until smoke ceased to issue from the top. In every instance the pottery was blackened and in every instance, too, the black penetrated below the surface, in some cases the ware becoming grey through to the centre. There is not any layer of soot on the surface of this blackened pottery and it may be handled freely without soiling the hands and even when rubbed with a clean white fabric this is only slightly discoloured.

In this connexion it may be mentioned that, although s
consists of solid particles, these are very minute, being of t
of from about one-thousandth of a millimetre to about o
thousandth of a millimetre in diameter[1] and they are
they cannot separately be seen by the naked eye
'smuts' observed when a chimney or lamp smo
scientifically meant by smoke, but immensely
be pointed out, too, that the ancient pottery
nature and that in any application of smoke,
penetration of the smoke would be aided by
air in the pores of the pottery as cooling progre
tion during baking of any organic matter present
intensify any black colour due to smoke, especially
the ware.

Although, as shown, pottery undoubtedly does be
blackened, but blackened throughout in the presence of
it has been stated by several writers[2, 3] that the smoke is no
factor; that smoke cannot penetrate pottery and that the
is not due to the smoke but is caused by reducing ga
the smoke that convert the red oxide of iron

[1] W. E. Gibbs, *Clouds and Smoke*, p. 130.
[2] W. M. F. Petrie, *The Arts and Crafts of*
[3] E. J. Forsdyke, *The Pottery called M*
Studies, xxxiv (1914), p. 139.

modification. Whether such a change can or does take place may now be discussed.

That the colour of black pottery may be due to the presence of black oxide of iron produced from red oxide by the action of reducing gases in the fire is theoretically possible and from a chemical point of view is very attractive, but that any such reduction actually occurred during the baking of Egyptian black and black-topped ware has not been proved. The available facts may now be considered.

Frankfort states[1] that a black colour due to black oxide of iron produced from red oxide by reduction 'can clearly be distinguished' from a black colour due to carbonaceous matter because the former is changed back to the original red on heating (from which the black may be regenerated by further reduction), whereas the latter is burned out and disappears. This argument, however, contains several omissions and fallacies. Thus the nature of the clay is not taken into account and, although it is true that if black pottery when heated becomes 'pale yellow-red' the black must have been due to the presence of ...ceous matter (including smoke), which has been burned out by ...there is more than this, namely, that the clay must either ...e from iron compounds or contained them in only very ... or that these must have been of such a kind, or were ...um carbonate in such a manner, that they did not ... heated. And the fact that certain black pottery ... is not proof that the black was due to black ... ld be shown that the clay was not of the red- ...y blackened by carbonaceous matter (including ... exactly in the same manner if the clay were a ... difference in the behaviour of the two kinds of ...red to by Frankfort almost certainly was due to ...ne was made from a red-burning clay and the other

...ears to be a certain amount of confusion respecting ... iron (the black colour of ancient pottery having ...ed by different writers to different oxides, for example, ...d Forsdyke[3] to ferrous oxide; by Petrie[4] to magnetic

...s *in Early Pottery of the Near East*, I, p. 10.
... p. 10; II, p. 65, *n.* 2; p. 141, *n.* 2.
... 137–9.
...s *and Crafts of Ancient Egypt*, p. 130; (*b*) in ... 67; (*c*) *Diospolis Parva*, p. 13; (*d*) W. M. F. ...allas, pp. 12, 37.

oxide and by Franchet[1] partly to ferrous oxide and partly to magnetic oxide) these oxides may be considered.

There are three oxides of iron: ferrous oxide, which is black; ferrous-ferric oxide or magnetic oxide, which is also black and ferric oxide, which is red. Manifestly, therefore, any black oxide must be either ferrous oxide or magnetic oxide.

Ferrous oxide may be produced in the laboratory by heating ferric oxide either in a current of hydrogen to about 300° C.[2, 3] or in an atmosphere of hydrogen and steam to a much higher temperature (700° C. to 1000° C.[3]). Neither of these temperatures, however, is that at which primitive pottery was baked, 300° C. being too low and 700°–1000° C. too high, the dehydration temperature of clay being about 500° C. to about 600° C. Also the atmosphere surrounding fired in a primitive manner is neither an atmosphere of hydrogen of hydrogen and steam at any time and, although a very small of hydrogen might have been produced by the combustion this could not possibly have continued to exist in the open fire, but would at once have been burned by the of water vapour. Another and insuperable objection ancient pottery being due to ferrous oxide is that extremely unstable substance, which cannot be which is oxidized immediately it is formed. I mention ferrous oxide, not being chemists, but a ferrous compound that for the sake regarded as consisting of this oxide combined stance, such for instance as silica, but in which separate identity, the real body present is ferrous silicate. This would seem to be instance[4] by a reference to the Staffordshire blue which is probably due to ferrous silicate) as an example of ferric oxide to ferrous oxide. As, however, the black, its colour cannot be any proof that the colour pottery (which is very black and not blue-black) or ferrous silicate. Moreover, the Staffordshire in a modern kiln, where the air condition and where a reducing atmosphere may

[1] L. Franchet, *Céramique primitive*, p.
[2] T. Turner, in *A Dict. of Appli* p. 677.
[3] Roscoe and Schorlemmer, *A*
[4] E. J. Forsdyke, *op. cit.*, p.

tained, whereas the early ancient black pottery was fired in a primitive manner in an open fire with an atmosphere that cannot have been a reducing one. The absence of a highly oxidizing atmosphere, as proved by the presence of smoke, is sometimes taken to mean that, therefore, the atmosphere must be a reducing one, but this is not so. The presence of smoke indicates a comparatively low temperature and the partial exclusion of air, but not necessarily the presence of a reducing atmosphere, this being not merely the absence of the usual complement of oxygen, or even the momentary presence of small proportions of reducing gases, but the presence of a considerable proportion of such gases operating over a somewhat lengthy period of time.

'agnetic oxide, which Petrie states is the colouring matter of the black pottery, may be produced in the laboratory by reducing 'ide by means of hydrogen or carbon monoxide at a tem- ' ° C.[1] or by a mixture of hydrogen and steam at 400° C.,[2] method of baking did not provide an atmosphere of 'onoxide, hydrogen and steam, or a reducing 'd. Ferric oxide also may be converted into 'g it to a very high temperature (above that it is improbable could have been 'ns of the firing of primitive pottery. 'e is heated in a reducing atmosphere it is Also if the black is magnetic oxide, it 'ot so. When powdered and tested with are found that are magnetic, but these 'antity to account for the black colour n is a common constituent of Egyptian of this material present in the black pottery to the clay, and has not been produced by red oxide during baking.[5]

'iven that the black of the ancient Egyptian .e to black oxide of iron are negative ones, but 'ive proofs, namely, first, that a large number 'nt and modern Egyptian black ware have

'rnal Chemical Society, Abs. CXXVIII (1925),

'220.

'ares, in Proc. Royal Soc., A,

been analysed by me and the presence of carbon (smoke) proved chemically in every instance, and second, that pottery made from grey-burning clay without any wash of red ochre, where there is not any red oxide to be reduced, may be blackened by smoke in the manner described.

The presence of carbon was proved by strongly heating finely powdered specimens of the black ware with lead chromate and passing the evolved gas into lime water, which was turned milky every time, thus showing that the gas produced was carbon dioxide, and hence that carbon had been present in the pottery.

Red Ware

Among the brown smoke-stained pots at first pro-
probably would have been an occasional one that was
happened to have been better baked than usual ar
brighter fire became more common, so the colo
improve, until eventually a good red would
meanwhile it was discovered that a red c
coating the pots with red ochre.

The various shades of red (including
caused by the presence of red oxide of
the use of clay containing a relatively
pounds of such a nature that they b
when strongly heated, but, as alread
caused by the application of red ochre t

Red pottery may be either uniform
generally (especially in the case of the t
is red on both surfaces, but grey or black
zone varying from a thin line to a broad ba
due to the carbonization of organic matter, eitl
impurity in the clay in the form of decayed
origin (humus), an occurrence by no means infr
added in order to temper the clay. Wh
matter is heated with free access of a
carbonizes and becomes black, the a
and slowly extending inwards, an
or the heat considerable or lon
gradually burns away, with
compounds into red oxid

great or not of long duration, the organic matter in the thickness of the ware is merely charred and remains, giving a grey or black colour to the zone in the centre. In order to produce a good red surface, not only must the clay be of the right kind, but the fire must be hot and free from smoke at the end of the baking and, with such a fire, any smoke stains produced in the earlier stages of the baking are burned off.

When a red colour other than paint is applied to the surface of a vessel, it is always in the form of a red ferruginous earth made into a wash with water. As this red is a natural earthy form of hæmatite, it is often termed hæmatite, but it will save confusion and will serve distinguish it from the black opaque mineral with a metallic lustre ved for beads, amulets and other small objects, if it be given and more correct name of red ochre.

w of the last edition of this book, I was accused of lack of confusing slip and wash, because I called the coating sh (whereas the reviewer considered it to be a slip) contains a small proportion of clay. The matter ion and if a slip consists of finely levigated, ith water, then red ochre applied to a pot

l wash on ancient Egyptian pottery is Polishing so modifies the surface of fferently, which naturally affects the a wash when there is none.

nd red pottery, a pot partly black and at an early date, probably as the result of a few such pots. The Badarian and wares take the form of a black top, with , to an otherwise red vessel.

ck-topped ware, like that of the entirely black is a carbon black, that is to say it is a smoke iron black, as often stated. The proofs of eady given for the entirely black ware

le, as the formation of this com- it be ferrous silicate, since this

Predynastic Pottery Pigments, vers, pp. 181–5.

is not black, but bluish-grey; although the black may contain a few magnetic particles derived from the clay used, it is not magnetic and, therefore, it cannot be magnetic oxide; the atmosphere of the open fire employed for baking the early pottery, although it may have contained a very small proportion of reducing gases (chiefly carbon monoxide), could not have been a reducing one of the kind or to the extent required to reduce red oxide of iron to black oxide, the presence of smoke not being evidence (as it is sometimes thought to be) of a reducing atmosphere, but merely a sign of the absence of a highly oxidizing one, which is only a negative condition, whereas a reducing atmosphere means the positive presence of a large proportion of reducing gases; also, when ferric oxide is heated in a reducing atmosphere it is usually metallic iron that is produced; the black, too, always gives the reactions for carbon (smoke) when tested. Moreover, the black top and black interior may be duplicated under conditions that make it impossible that it should be the product of the reduction of red oxide to black oxide, these conditions being the very short time (a few minutes only) necessary to produce the blackening, the rapidly falling temperature of the pottery during the operation and particularly that the black may be produced in the absence of red oxide with clay (without any wash of red ochre), that is not red-burning but grey-burning. Finally, it may readily be proved that the black is not due to any compound (whether ferrous oxide, ferrous silicate or magnetic oxide) formed by the reduction of red ferric oxide by taking two sherds, if possible from the same pot, one from the red body and the other from the black rim, reducing the red of the former in the laboratory by means of hydrogen and comparing the result with the black sherd. The difference is very marked. The colour of the treated sherd is a dark bluish-grey and not black, and on powdering it and adding hydrochloric acid an immediate and vigorous reaction is produced, and on continued treatment practically all the colour disappears, leaving a very light-grey (almost white) coloured residue from which carbon and carbonaceous matter are manifestly absent. If the experiment has been carried out with due precautions against oxidation, the solution on testing is found to contain iron compounds in the ferrous condition. In the case of the sherd originally black, this, under identical conditions, shows no immediate or pronounced action with the acid and, even after prolonged treatment, the residue remains black; there are no ferrous compounds in the solution and the black gives the tests for carbon.

Before being in a position to explain the mode of production of this black-topped ware, it is necessary to know something more about it than the mere fact that one part of a pot is red and another black, and the detailed description of this pottery may, therefore, be given.

The outside of the body of the pot is red, this red being generally thicker than can be accounted for by a red wash and, therefore, the ware itself must have been baked red; the red does not penetrate through the ware, nor even as a rule to the centre, but there is always a thick black stratum below it; a little red occasionally may be seen on the rim (generally inside) amid the black,[1] showing that the surface originally had been red and subsequently was covered with black, some of the red, however, having escaped the action, and, what is most significant, when the black is scraped off carefully there is red below, which can only mean that the red has not been changed into black but that it has been covered with black. The top (mouth) of the pot and often also the interior are black.

There are only two ways in which such pottery could have been made, namely, (*a*) by the simultaneous production of the red of the body (apart from any wash of red ochre) and the black of the interior and rim, or (*b*) by producing ware wholly red first and then by a secondary operation blackening the interior and rim.

The first method was adopted by H. L. Mercer, a pottery manufacturer of Pennsylvania, who in one continuous operation made excellent imitations of the red-bodied black-topped ware, which are now in the Pitt-Rivers Museum at Oxford. His description of the process is as follows[2]: 'Having made a pot of ferruginous clay which in a clear kiln fire would burn red, I rubbed red ochre diluted in water upon it with the hand when half dry. Immediately polishing the surface by rubbing with the circumference of a blown glass bottle in lieu of a pebble, I next thoroughly dried the pot and then stood it upside down with the rim buried an inch deep in a layer of rather fine white pine sawdust in the centre of which immediately under the vessel I placed a piece of resin of the size of a chestnut. Over the bowl thus arranged I so bent a piece of common wire netting (meshed at about two inches) as to entirely surround and overarch the pot at a distance from it of

[1] As examples of this may be mentioned pots Nos. 2002, 2007, 2012, 2015 and 18812 (and probably others) of those described by von Bissing (Fr. W. von Bissing, *Tongefässe*, 1).

[2] H. L. Mercer, in *Areika* (D. Randall-MacIver and C. L. Woolley), p. 17.

about two inches. Both wire and sawdust stood within a circle of about three feet in diameter of loosely piled stones about one foot high. Upon this I threw about a bushel of finely chipped dry rye straw so as to fill the stone circle and entirely cover the bowl and wire. The straw when ignited burnt about three-quarters of an hour, leaving the pot when cool a duplicate (even to the waving buff-grey zone below the black) of the original specimen.'

At one time I thought and stated[1] that some such process as that of Mercer (without of course the wire netting, but with some other method of keeping the fuel from close contact with the pot) had been practised anciently and, although this may have been so (as manifestly it is not impossible) I am unable to conjecture how it could have been done, and Petrie, who first suggested this method,[2] gives no explanation beyond that the pots were baked mouth downwards with the rims in the ashes. It may be pointed out, too, that in order to bake a large number of pots together with all the rims in the ashes, a considerable area of ground would have been required. Ashes, too, are produced only towards the end of the baking, when the smoke is over. I now think it more likely that the method employed consisted of two distinct operations (as in the making of modern black pottery in Egypt), the first being the making of a red pot (the red of the clay being enhanced in some instances by a wash of red ochre) and the second being the subjecting of the rim and interior of the pot to the action of dense smoke in order to blacken them, this second operation (first suggested as being likely by Mr. J. W. Crowfoot)[3] being analagous to that practised in the Sudan and elsewhere at the present day and already described,[4] but instead of the whole pot being covered with chaff or other material, which produces a pot entirely black, the rim only would have been covered, as only this and the interior had to be blackened.

The obvious way of carrying out the operation seemed to be to stand the pots red-hot from the fire mouth downwards on the fuel and this method, therefore, was tried.[5] Miniature pots of two different kinds of clay were procured from a local potter, who supplied them

[1] A. Lucas, *The Nature of the Colour of Pottery*, in *Journal Royal Anthrop. Inst.*, LIX (1929), pp. 127–9.

[2] W. M. F. Petrie, *The Arts and Crafts of Ancient Egypt*, p. 130.

[3] A. Lucas, *op. cit.*, p. 129, *n.* 2.

[4] See p. 424.

[5] A. Lucas, Black and Black-topped Pottery, *Annales du Service*, XXXII (1932), pp. 93–6.

wet; these were partially dried, coated with a thin wash of red ochre by smearing it on with the fingers, polished with a quartz pebble, thoroughly dried, baked in a small electric muffle furnace, and when red-hot placed mouth downwards on a layer of sawdust[1] (which was the fuel chosen) in which the rim was buried. The result was a red pot with a black rim and generally, though not always, a black interior, but the red body at first was almost always badly smoke-stained. In order to avoid this staining, various modifications of the method were tried and eventually it became clear that the exact temperature of the pots was of little importance, provided they were hot enough to char the fuel and not sufficiently hot to enflame it, and that the principal precaution necessary was to prevent the sawdust giving off smoke from the top, which could be done by manipulating it in such a manner that the smouldering took place entirely beneath the surface so that practically no smoke escaped, which was effected by pressing down the sawdust and covering it up with fresh material whenever any signs of burning manifested themselves, or better, by covering the sawdust, after the pot had been placed in position, with a thin layer of dry earth or sand.[2] There is not any thick layer of soot on the black rim or black interior, which may be handled without soiling the hands and, even when it is rubbed with a clean white fabric, this is only slightly blackened.

Another way of avoiding smoke stains on the bodies of the pots is by burying them, direct from the furnace, mouth upwards in sand, leaving only the rims exposed: covering the rims, while still hot, with sawdust and placing a little sawdust inside the pots. Although this method is very satisfactory in the laboratory, it might not be practicable on a large scale; to bury a number of red-hot pots upright and very quickly, before they have time to cool, in sand or earth is not easy and in winter the rims of the pots would probably cool so rapidly that they would not be hot enough to char the sawdust and, if the ground were wet, it would be impossible without cracking the pots.

Professor Gordon Childe, in collaboration with Professor Barger, carried out a few experiments, which were ' undertaken primarily to determine whether the highly burnished, light grey ware characteristic of " neolithic " sites on Malta should be assigned to the " reduced " or

[1] Anciently, chopped straw or chaff may have been used.

[2] It occasionally happened that a pot accidentally fell over on to its side in the sawdust, which charred in contact with the hot clay and stained the pot, and the black stains on the ancient pottery may have been caused in this manner.

:o the " carboniferous " group.' [1] Since any discussion of the whole subject would be, not only too long, but also out of place here, the results of only one of the experiments, that with Egyptian pottery, will be considered. The specimen used for the experiment was part of the black rim of a red-bodied, black-topped predynastic pot. This was heated for ten minutes to a dull red heat in a current of oxygen, when the black colour disappeared entirely, giving place to a deep red colour similar to that of the body of the pot. Carbon dioxide was given off, and, therefore, free carbon (due to smoke) was present. When subsequently heated in a reducing atmosphere the red colour disappeared and the sherd became deep black, though a slightly poorer black than it was originally.

Gordon Childe, while admitting that the Egyptian black-topped ware ' may contain free carbon,' suggests that the attribution of a grey or black colour in pottery, including Egyptian ware, exclusively to carbon is not justified. With respect to the Egyptian black and black-topped pottery, however, Gordon Childe refers to an article written by me in 1929,[2] but he does not seem to have noticed the results of later work published in 1932 [3] and 1934 [4] respectively, which have been summarized above, and which, in my opinion, prove definitely that the black of the Egyptian black and black-topped ware is due to carbon, since the presence of carbon has been determined by analysis and since, too, pottery made from grey-burning clay, without any coating of red ochre, where there is not any red oxide of iron to be reduced, may be blackened by carbon in a manner similar to that of the Egyptian ware.

Grey, Drab and Buff[5] *Ware*

The various shades of grey (generally ash-grey or greenish-grey), drab and buff of some of the ancient Egyptian pottery are due to the use of a special kind of clay (brownish-grey colour) practically free from organic matter (which is dark coloured and which darkens further on heating, unless it is entirely burned away) which, although it contained iron compounds, also contained a considerable proportion of calcium carbonate, since it is only such clays that become greenish-

[1] V. Gordon Childe, On the Causes of Grey and Black Coloration in Prehistoric Pottery, *Man*, No. 55 (1937).

[2] A. Lucas, *Journal Royal Anthrop. Inst.*, LIX (1929), pp. 113–29.

[3] A. Lucas, Black and Black-topped Pottery, *Annales du Service*, XXXII (1932), pp. 93–6.

[4] A. Lucas, *Ancient Egyptian Materials and Industries*, 1934, pp. 316–33.

[5] Buff means having a yellowish tint.

grey when strongly heated, although when only lightly baked they are often of a slight reddish tint, which is the opposite of what might be expected, and the opposite of what occurs with many clays, usually the greater the heat the redder the ware. The Qena and Ballas clays of which the modern *qulleh* and *ballas* are made are of this type.[1] Grey, drab or buff pottery occasionally shows a dark zone in the centre of the ware, which is due to the same cause as in the case of red pottery, namely the carbonization of organic matter present in the clay.

Decoration

Apart from any ornamentation of pottery by such means as a light-coloured clay slip, a red wash, smoke-blackening (either of the whole pot or of the top only) or burnishing, the ancient Egyptian pottery sometimes was decorated with incised or painted designs, or with painted figures or scenes, which may now be described.

Incised Designs. As examples of incised designs the brown or black Tasian ware, the Egyptian and Nubian black predynastic ware, and the Nubian brown or black C-group ware may be mentioned, all of which have geometrical patterns incised on them before firing, these incisions being filled in subsequently with white pigment, which, in the case of the Egyptian ware, Quibell states[2] was 'probably gypsum,' though he does not give any evidence in support of this. Another example of incised design is the 'rippling' of the finer kinds of Badarian pottery.

Painted Designs, Figures and Scenes. The early Egyptian painted pottery has been classified by Petrie as 'white cross-lined' and 'decorated' respectively.[3, 4]

The former is a red ware with a wash of dark reddish-brown (almost chocolate-coloured) oxide of iron, which was then polished and afterwards painted, before firing, with geometrical designs or with figures of plants, men and animals in a white, or yellowish-white, pigment. Petrie calls it 'polished red pottery with white cross-lines'[5] and says[5] that it 'is painted with a white slip clay upon the base of the

[1] An analysis of a present-day typical pottery clay from Ballas shows it to contain a comparatively large proportion of iron compounds (6 per cent) and more than 20 per cent of calcium carbonate. For details of analysis, see p. 550.

[2] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 13.

[3] W. M. F. Petrie, *Prehistoric Egypt*, pp. 14, 16.

[4] See T. E. Peet's 'The Classification of Egyptian Pottery,' *Journal of Egyptian Archaeology*, 19 (1933), pp. 62–4. Peet calls the classification 'faulty' and 'the paraphernalia of the Dark Ages.'

[5] W. M. F. Petrie and J. E. Quibell, *op. cit.*, p. 37.

polished red pottery.' In another place, however, he states[1] that 'This white paint was put over a bright red[2] facing of haematite'; Frankfort says[3] that it is made 'of ferruginous clay and bears rectilinear designs in chalky white paint on a red haematite wash' and Gordon Childe calls it[4] 'essentially red-polished ware ornamented with patterns in dull white paint.' After a comparatively short life this 'white cross-lined' pottery disappeared, giving place to the 'decorated' ware about to be described. Petrie's statement that the white pigment used was a white clay has been confirmed by Ritchie,[5] who analysed specimens from Armant. In this connexion it may be mentioned that a mass of white clay was found in the predynastic cemetery at Mahasna.[6]

The 'decorated' ware, which, though still predynastic, is later than the 'white cross-lined' ware, sometimes is of a drab colour and sometimes of a pale red colour with the painting (principally ships and wading birds, with occasionally men and animals), which was done, before the firing, with dark reddish-brown oxide of iron, which often has a slight purple tint. Sometimes patches of a pot are drab and other patches pinkish. The drab ware apparently was so much esteemed that occasionally it was imitated by putting a thin slip of a drab colour on a pale red-coloured pot before painting. The pale red ware is probably the same as the drab ware, but baked at a much lower temperature, since specimens that were strongly heated by me (to about 1000° C.) in an electric muffle furnace became greenish-grey.

Peet, describing the 'decorated' ware, says[7] it is 'unpolished with or without slip,' and that 'The clay is pink or buff'; Frankfort says[8] 'the paint is (except in a few cases) applied directly to the pinkish buff body of the pots without interposed slip'; Gordon Childe says[9] that the pottery is a 'light-coloured buff clay painted with patterns in brownish-red,' and Petrie says[1] 'The later prehistoric painting was in dull red on a buff body.'

I have examined sixty-nine specimens of this predynastic 'decorated'

[1] W. M. F. Petrie, *Arts and Crafts of Ancient Egypt*, 1910, p. 129.

[2] On the pots in the Cairo Museum examined by me this colour is dark reddish-brown and not bright red, as described by Petrie.

[3] H. Frankfort, *Studies in Early Pottery of the Near East*, I, p. 94.

[4] V. Gordon Childe, *New Light on the Most Ancient East*, p. 77.

[5] Sir R. Mond and O. H. Myers, *Cemeteries of Armant*, I, pp. 182, 184, 185.

[6] E. R. Ayrton and W. L. S. Loat, *The Predynastic Cemetery at Mahasna*, p. 12.

[7] T. E. Peet, *The Cemeteries of Abydos*, II, p. 12.

[8] H. Frankfort, *op. cit.*, p. 96.

[9] V. Gordon Childe, *op. cit.*, p. 90.

ware in the Cairo Museum and found that thirty-five (51 per cent) were drab, twenty-two (32 per cent) pinkish-drab, four (6 per cent) partly drab and partly pink, three (4 per cent) pale red with drab slip, and five (7 per cent) clear, bright pale red, which seems unlikely to have been the original colour, but which may be due to the unintentional removal of a drab coating by washing. Brunton says[1] 'The entire surface of most Predynastic decorated pots was covered with a thin whitish coat presumably that the paint should show up better than it would on the plain red pottery. This coat being easily soluble in water has generally disappeared, especially when the pots have been washed to clean them, or soaked for the removal of salt.' The paint is a similar dark reddish-brown in all cases.

Up to the time of this 'decorated' ware, the only clay employed for all Egyptian pottery was that brought down and deposited by the Nile, either in the Delta or in the Nile Valley, at the sides of the river, that from one locality differing from that from another locality principally in the degree of fineness of the particles and in the proportion of sand present, or in some places in Upper Egypt by the presence of numerous tiny flakes of mica. The clay of the drab ware, on the other hand, is not a Nile deposit, but is a desert product composed of an intimate mixture of very fine clay and very fine calcium carbonate (carbonate of lime), which has been washed out of the limestone hills that border the Nile Valley and deposited at, or near, the mouths of certain smaller valleys that enter the main river valley, two well known localities for this clay being Qena and Ballas, both in Upper Egypt, where the deposits have been exploited from an early period. Other, but less important, deposits occur in Middle Egypt, as for instance at Sohag.[2] Geologically this material is a calcareous clay or marl.

The Nile Valley clay always burns to a brown or red colour, whereas the calcareous clay becomes of a pale red or pinkish colour when lightly burned, and drab, buff, or greenish-grey when strongly burned, the stronger the heat the greener the resulting colour, which accounts, not only for the varied colours of the ware, but also for the fact that sometimes a pot meant to be drab may be partly or wholly pink, owing to the heat not having been very strong, or not uniform. But the high temperature necessary to produce drab-coloured ware may also produce a purple tint in the red oxide of iron used as a pigment, certain kinds

[1] G. Brunton, *Annales du Service*, XXXIV (1934), p. 153.
[2] G. A. Reisner, *Kerma*, p. 321.

of red oxide of iron becoming purplish when strongly heated.[1] With reference to this purple colour Mackay writes[2] ' A warm purplish black was used on much of the predynastic pottery of Egypt. It has a manganese base and was especially suited to withstand the heat of the furnace when the jar was baked.' The colour of the pigment of the Egyptian predynastic ' decorated ' ware, however, is never quite black and, therefore, it cannot be black oxide of manganese, nor does black oxide of manganese become purple when strongly heated. It is true that a purplish colour in glaze and glass is often due to the use of oxide of manganese, which forms a purple compound with other ingredients present, but when oxide of manganese is merely painted on a pot and heated, such purple compounds are not formed, whereas certain oxides of iron become purple when heated, and the purple colour, therefore, is an indication that the pigment consists of oxide of iron and not of oxide of manganese. That this actually is so I have proved by the analysis of specimens of this purple colour from predynastic ' decorated ' pots, and I have found that in every instance it consisted of oxide of iron and was free from manganese compounds. Since the painting was done before firing, a carbon-black pigment could not be employed, as the carbon would have burned off during firing, and, so far as is known to me, a black pigment, although in early and common use for tomb painting, was not used for pottery before the Eighteenth Dynasty, when it was applied after firing.

The Eighteenth Dynasty pottery may now briefly be considered. The nature and colour of certain pottery wine jars from the end of the Eighteenth Dynasty (tomb of Tut-ankhamun) have already been dealt with. Other pottery of this same dynasty from El Amarna and Giza respectively examined by me was a drab-coloured ware painted with light blue, red and black pigments after firing. The blue was the usual Egyptian blue frit; the red was red ochre and the black was carbon. In one instance of drab ware, however, a black pigment consisted of oxide of manganese, and in one instance of red ware with a yellowish-white slip, the black pigment, although possibly intended to be oxide of manganese, was actually black oxide of iron containing a very small proportion of oxide of manganese, these two oxides frequently occurring naturally together. A few specimens of painted pottery of Eighteenth Dynasty date are varnished.[3]

[1] J. W. Mellor, *Inorganic and Theoretical Chemistry*, XIII, pp. 782–3.
[2] E. Mackay, *Report on Excavations at Jemdet Nasr, Iraq*, p. 232.
[3] Cairo Museum, Nos. J. 72517, 72518.

CHAPTER XVI

PRECIOUS AND SEMI-PRECIOUS STONES

The stones used in ancient Egypt for amulets, beads, jewellery, scarabs and other personal ornaments, although doubtless all costly and highly prized at the time, include many that nowadays would not be called precious, but, at the most semi-precious and in some instances not even that. Many of these stones also were employed as inlay for the decoration of boxes, coffins, furniture and other objects.

The principal stones used were agate, amethyst, beryl, calcite, carnelian, chalcedony, coral, felspar, garnet, hæmatite, jade, jadeite, jasper, lapis lazuli, malachite, olivine, onyx, pearl, peridot, rock crystal, sard, sardonyx and turquoise. With these it will be convenient to include amber and other resins, which, although not stones, were regarded as semi-precious materials and sometimes were used for many of the purposes of gem stones. The diamond, opal, ruby and sapphire were not known to the ancient Egyptians.

Precious stones are mentioned frequently in the ancient records as having been employed for particular purposes and as having been received as tribute or taken among the spoils of war and, although some of these stones are referred to individually by name, the translation of the names is still often uncertain. Pliny mentions about thirty different kinds of precious stones obtained from Egypt and Ethiopia,[1] but only a few of these can be identified.

Many of the stones enumerated were employed as early as Badarian and predynastic times, while others only came into use at a very late period and, with a few exceptions, they were all local products.

Agate, Onyx, Sardonyx

Agate, onyx and sardonyx are all banded forms of chalcedony and, being very closely related, they are often classed together as agate; they all consist of silica,[2] the principal difference between them being

[1] XXXVII.

[2] Where silica is mentioned as distinct from quartz, this means that the material, although of the same composition as quartz, is not crystalline.

in the colour of the bands: in agate, the bands, which are frequently irregular and ill-defined, but usually more or less concentric, are generally white and brown, with sometimes a little blue; in onyx and sardonyx the bands are generally straight and comparatively regular, in onyx being milk-white alternating with black and in sardonyx white alternating with reddish-brown or red, this stone, as its name indicates, consisting of onyx stratified with bands of sard. The greater part of the agate, onyx and sardonyx, especially the onyx, used for jewellery at the present day is artificially stained.

Agate occurs plentifully in Egypt, chiefly in the form of pebbles, but it has been found also in small quantity associated with jasper and chalcedony in a dyke rock at the head of Wadi Abu Gerida in the eastern desert.[1] Onyx and sardonyx probably also occur in Egypt, though no mention of them can be found in the geological reports. Pliny refers to Egyptian agate from Thebes and states that it is destitute of red and white veins and is an antidote to scorpion poison.[2]

Agate pebbles have been found in predynastic graves[3] and both agate beads[4, 5] and onyx beads[6] of this date are known. The earliest use of sardonyx that can be traced is from the Twenty-second Dynasty,[6] and the disks from the Nineteenth Dynasty temple of Meneptah at Memphis, but certainly of later date,[7] called onyx by the finder, appear from the description (white, red and brown) to be sardonyx. The principal use of these three stones for jewellery was at a late period, from about the Twenty-second Dynasty onwards, but more especially during the Greek and Roman epochs. Recently a very fine set of agate vessels, of unknown but probably Roman date, has been found at Qift in Upper Egypt, six of which are in the Cairo Museum[8] and two (the largest) in the hands of a dealer. These probably came from India and are 'murrhine' vessels, such as Pliny describes.[9] At a late date agate and onyx beads were imitated in glass.

[1] T. Barron and W. F. Hume, *The Topog. and Geol. of the Eastern Desert of Egypt, Central Portion*, p. 266. W. F. Hume, *Geology of Egypt*, Vol. II, Part III, p. 862.

[2] XXXVII: 54.

[3] W. M. F. Petrie, *Prehistoric Egypt*, p. 44.

[4] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 10, 44.

[5] W. M. F. Petrie, G. A. Wainwright and E. Mackay, *The Labyrinth, Gerzeh and Mazghuneh*, p. 22.

[6] Examples in the Cairo Museum.

[7] W. M. F. Petrie, *Memphis I*, p. 12; Pl. XXVIII (12).

[8] R. Engelbach, *Annales du Service*, XXXI (1931), pp. 126–7; Pl. I.

[9] XXXVII: 7, 8.

Amber and other Resins

Although amber and other resins are neither precious nor semi-precious stones, they may conveniently be included here as they were used for amulets and in jewellery in the same manner as these stones.

Petrie mentions two inscribed scarabs that he terms amber[1] and the large scarab in the pectoral of Hatai of the Twenty-first Dynasty[2] and a scarab of uncertain date in the British Museum[3] are both called amber. That amber may have been used by the ancient Egyptians, especially at a late date, is not denied, but that all the objects termed amber are indeed amber has not been proved, and some at least are almost certainly other kinds of resin, lumps of which are very common in ancient Egyptian graves of all periods, particularly in those of Badarian, predynastic and early dynastic date. Worked resin that is not amber is also known, for example, in the tomb of Tut-ankhamun,[4] there was a double finger ring of resin engraved with the royal cartouches; two large resin scarabs, one having a bird carved in relief on the surface; a necklace of about fifty-five resin beads graduated from comparatively small ones to very large ones; a necklace of alternate resin and lapis lazuli beads; a pair of earrings made up of alternate resin and gold beads; a broken object (gold mounted) of resin, probably one of a pair of earrings; a hair-ring of resin; two knuckle bones of resin and a resin knob of a box. The resin of all these objects is very brittle, dark red by transmitted light and almost black by reflected light; I believe it is not amber, principally on account of its ready solubility in many of the ordinary organic solvents, for example, alcohol and acetone in which amber is only slightly soluble. Small resin beads from periods other than the Eighteenth Dynasty are also known and these, too, whenever I have tested them have been found to be easily soluble in alcohol and many other organic solvents and, therefore, it is improbable that they are amber, a characteristic feature of which is its very slight solubility in such solvents.

Doran analysed several predynastic resin beads found by Myers at Armant and he says 'The evidence, so far as it goes, supports the assumption that specimens Ar. 1403 and Ar. 1424*a* are natural amber. . . . They show differences from the characteristics ordinarily assigned to amber, but these differences are of the same order and of a kind

[1] W. M. F. Petrie, *Scarabs and Cylinders with Names*, p. 9.
[2] E. Vernier, *Bijoux et orfèvreries*, p. 397.
[3] H. R. Hall, *Scarabs*, p. 12.
[4] A. Lucas, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter, p. 184.

which is consistent with age-long maturing of the resin.'[1] Is it justifiable, however, to assume that amber, which had already undergone 'age-long maturing' before it was found and used by man, undergoes further alteration when kept for a few thousand years more?

Pliny quotes Nicias for the statement that amber was produced in Egypt,[2] which, however, is not so.

Amethyst

Amethyst consists of transparent quartz coloured by a trace of some compound of manganese: it was used largely in ancient Egypt in the form of beads, chiefly for necklaces, but also for bracelets, and occasionally was cut into scarabs. From the First Dynasty there are bracelets containing amethyst beads: it was much employed during the Middle Kingdom, occasionally during the Empire (for example two amethyst scarabs were found in the tomb of Tut-ankhamun) and its use continued until Roman times. The predynastic bead from Naqada, now in the Museum of University College, London, where I have examined it, which Petrie calls amethyst,[3] although it looks somewhat like very pale amethyst is certainly not amethyst, as it can be scratched with a knife.

Amethyst workings of ancient date exist near Gebel Abu Diyeiba in the Safaga district of the eastern desert,[4, 5] the stones occurring in cavities in a red granite; there are also ancient workings about 20 miles south-east of Aswan[6] and others of Old Kingdom date about 40 miles north-west of Abu Simbel.[7] Pliny refers to Egyptian amethyst.[8]

Beryl

Beryl may be green, pale blue (aquamarine), yellow or white, but so far as is known, only the green variety occurs in Egypt or was used by the ancient Egyptians.

[1] W. Doran, *Cemeteries of Armant*, I, Sir R. Mond and O. H. Myers, pp. 96–100.
[2] XXXVII: 11.
[3] W. M. F. Petrie, *Prehistoric Egypt*, p. 44.
[4] Mines and Quarries Department, *Report on the Mineral Industry of Egypt*, 1922, pp. 37–9.
[5] G. W. Murray, in *Cairo Scientific Journal*, VIII (1914), p. 179.
[6] L. Nassim, *Minerals of Economic Interest in the Deserts of Egypt*, in *Congrès Int. de Géog., Le Caire, Avril, 1925*, III (1926), p. 167.
[7] O. H. Little, *Annales du Service*, XXXIII (1933), p. 80. G. W. Murray, The Road to Chephren's Quarries, *Geog. Journal*, 94 (1939), p. 105.
[8] XXXVII: 40.

Beryl occurs in the Sikait-Zubara region of the Red Sea hills, where there are extensive old workings,[1, 2, 3] probably of Graeco-Roman age, and there is not any evidence that the mines were worked in the reign of Amenophis III as stated by Wilkinson.[4] These mines are mentioned by Strabo[5] and Pliny[6] and probably were the original and only source of beryl in classical times. The stones are found in mica-talc schists in the form of hexagonal prisms having characteristic vertical striations. Several attempts have been made in modern times to re-open the mines, all of which have proved commercial failures largely because the stones are not of sufficiently good quality for modern requirements, being often of a pale green colour and full of flaws. Stones of a good enough quality to rank as emeralds (the emerald being only a particularly good quality beryl[7]) may have been found in the past, but none such has been found in modern times. Beryls are always transparent or translucent and never opaque. Beryl was used in Egypt at first in the form of the natural hexagonal crystals in which it occurs, since being slightly harder than quartz the Egyptians were unable to cut it satisfactorily until a later date, although it was sometimes bored.

So far as can be ascertained, beryl was never used in ancient Egypt until a late period and chiefly from Ptolemaic times and all the stones of earlier date called beryl that have been examined by me have been found not to be beryl. Thus the stones in the Dahshur jewellery called emerald and Egyptian emerald when first described[8, 9, 10] are green felspar: the stone of Twentieth Dynasty date called an uncut emerald[11] is also green felspar: the beads of Twelfth Dynasty date from Naqada[12] are most unlikely to be beryl at that period: the green

[1] Mines and Quarries Department, *Report on the Mineral Industry of Egypt*, 1922, pp. 37–9.

[2] G. W. Murray, in *Journal of Egyptian Archaeology*, XI (1925), pp. 144–5.

[3] W. F. Hume, *Geology of Egypt*, II (Part I), pp. 107–25.

[4] G. Wilkinson, *The Ancient Egyptians*, II (1890), p. 237.

[5] XVII: 1, 45. [6] XXXVII: 16–8.

[7] Beryl and emerald have the same composition, both being double silicates of beryllium and aluminium, the only difference between them being one of quality, the deeper coloured and more transparent variety being called emerald and the lighter coloured and less transparent stones being beryl.

[8] J. de Morgan, *Fouilles à Dahchour, mars-juin, 1894*, pp. 60, 63, 64, 66–70, 112–4.

[9] J. de Morgan, *Fouilles à Dahchour en 1894–1895*, pp. 51, 53, 58–65.

[10] In several instances Vernier repeats de Morgan's mistake, for example, J. de Morgan, *Fouilles à Dahchour, mars-juin, 1894*, p. 66; Pl. XX (15, 16), and E. Vernier, *Bijoux et orfèvreries*, Nos. 52026–7, p. 21.

[11] G. Maspero, *Guide to the Cairo Museum*, English trans., 1903, p. 519.

[12] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 45.

stone in the three Twelfth Dynasty scarabs[1] and that of the two Eighteenth Dynasty scarabs[1] described as beryl have been examined by me and are not beryl (the other Eighteenth Dynasty scarab also described as beryl could not be found, but it is very improbable that it is beryl). Petrie states[2] that ' Beryl or emerald is unknown in scarabs and was only worked after the cessation of scarab making.' The amulets, beads and pendants (predynastic, early dynastic and New Empire) found in Nubia and called beryl[3, 4] are almost certainly none of them beryl, as some of the beads that were later submitted to me for verification were olivine and some green felspar. There are large beryls in the silver jewellery discovered by Emery at Qustul in Nubia.[5] Beryl objects were found at Coptos,[6] but no particulars are given, and beryl amulets stated to be of about the end of the Twenty-sixth Dynasty[7] and of the Thirtieth Dynasty[8] respectively are recorded.

Calcite, Iceland Spar

Calcite is simply the geological name for what is termed alabaster in Egypt; in thin plates it is translucent and in this form it was employed as inlay for jewellery and furniture, for example on some of the objects from the tomb of Tut-ankhamun.

A very pure and transparent variety of calcite termed ' Iceland spar ' was used occasionally for small objects, a cylinder seal of this material from the Sixth Dynasty being known[9] (though Iceland spar is neither glass-hard nor natural glass as stated in the description), as also beads of the Eighteenth, Twenty-second and Twenty-third Dynasties respectively.[2] Brunton reports a green calcite bead of Badarian date.[10] The transparent cover of the small ' ox ' pendant from Dahshur is not Iceland spar (*spath*) as stated by the finder,[11] but rock crystal.

[1] P. E. Newberry, *Scarab-shaped Seals*, Nos. 36326, 37487, 37410, 37413, 37419.
[2] W. M. F. Petrie, *Scarabs and Cylinders with Names*, p. 8.
[3] G. A. Reisner, *Arch. Survey of Nubia, Report for 1907–1908*, pp. 33, 35, 123, 132.
[4] C. M. Firth, *Arch. Survey of Nubia*, (*a*) *Report for 1908–1909*, pp. 62, 78; (*b*) *Report for 1909–1910*, pp. 53, 74, 97; (*c*) *Report for 1910–1911*, p. 221.
[5] W. B. Emery, *The Royal Tombs of Ballana and Qustul*, pp. 110, 183, 185, 187, 189, 191, 197, 198, 258.
[6] W. M. F. Petrie, *Koptos*, p. 26.
[7] W. M. F. Petrie, *Kahun, Gurob and Hawara*, pp. 18–9.
[8] W. M. F. Petrie, *Abydos*, I, p. 38.
[9] H. R. Hall, *Cat. of Egyptian Scarabs*, p. xxvi.
[10] G. Brunton, *Mostagedda*, p. 36.
[11] J. de Morgan, *Fouilles à Dahchour en 1894–1895*, p. 67.

All varieties of calcite occur abundantly in the eastern desert of Egypt, Iceland spar being found west of Asiut (from which place there is a fine specimen in the Geological Museum) and also at El Amarna.

Carnelian, Sard

Carnelian is a translucent red chalcedony, the colour being due to the presence of a small amount of oxide of iron; in the form of pebbles it occurs abundantly in the eastern desert of Egypt and certainly in one locality at least in the western desert[1]: it was much used from predynastic times onwards,[2] at first for beads and amulets and later also for inlay for jewellery, furniture and coffins, and occasionally for finger rings. In the Cairo Museum there is a decorated (etched) carnelian scaraboid of the Eighteenth Dynasty (possibly of Amenophis III[3]). This is the only example of decorated carnelian known to me from Egypt, though this technique is very common from India and Mesopotamia. Myers found a few glazed carnelian beads of predynastic date at Armant.[4]

During the Eighteenth Dynasty an imitation carnelian consisting of translucent quartz set in a red cement often was employed to supplement the genuine article as inlay, for instance, on two of the coffins of Yuya; on the coffin formerly supposed to be that of Akhenaten, but now thought to be that of Smenkhkere and on several of the objects from the tomb of Tut-ankhamun, including the mask, the four miniature canopic coffins and the large gold coffin.

Sard is the name applied to the darker varieties of carnelian, some of which are almost black: it was used to a small extent from predynastic times onwards.[5] Pliny states[6] that sard occurs in Egypt, which is probably so.

Chalcedony

Chalcedony is a form of silica, translucent and somewhat waxy in appearance and, when pure, white or greyish-white in colour with often a slight bluish tint: it may, however, be of almost any colour

[1] G. W. Murray, The Road to Chephren's Quarries, *Geog. Journal*, 94 (1939), p. 105.

[2] W. M. F. Petrie, *Prehistoric Egypt*, p. 44: G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 56.

[3] W. M. F. Petrie, *Historical Scarabs*, 1889, No. 819. Museum No. $\frac{1}{2}\frac{4}{6}|\frac{5}{4}$

[4] Sir R. Mond and O. H. Myers, *Cemeteries of Armant*, I, p. 72.

[5] W. M. F. Petrie, G. A. Wainwright and E. Mackay, *The Labyrinth, Gerzeh and Mazghuneh*, p. 22.

[6] XXXVII: 31.

owing to the presence of a small proportion of impurity, many of the coloured varieties having special names.

Chalcedony occurs in Egypt near Wadi Saga[1] and in Wadi Abu Gerida[1] in the eastern desert; in the Baharia Oasis of the western desert[2]; about 40 miles north-west of Abu Simbel[3]; in the Fayum province[2] and in Sinai.[2] It was employed occasionally in ancient Egypt for beads, pendants, and scarabs, its use dating as early as predynastic times,[4] and as late as the Roman period.

Chrysoprase

Chrysoprase is an apple-green coloured variety of chalcedony. A pendant of predynastic date found at El Amrah is stated to be chrysoprase,[5] as also a fish and an amulet of unknown date.[6]

Coral

Coral consists of the hard skeletons of various marine organisms and it may be white, various shades of red, or black in colour. Only the white and red kinds need be considered, as there is not any record of the black variety having been used anciently, although it occurs in the Mediterranean.

Two instances of the ordinary white coral having been used in ancient Egypt which can be traced were respectively at Gurob (Nineteenth Dynasty)[7] and at Defenneh (seventh to sixth century B.C.), at which latter place there was a large quantity in the form of natural branches.[8]

There are two varieties of red coral, one the well known, solid, branching kind (*Corallium nobile; Corallium rubrum*) used at the present day for jewellery, especially for necklaces, and the other the lesser known 'pipe' or 'organ' coral (*Tubipora musica*), which, as the name indicates, occurs in the form of hollow tubes, the appearance of which is somewhat suggestive of miniature organ pipes.

[1] T. Barron and W. F. Hume, *Top. and Geol. of the Eastern Desert of Egypt, Central Portion*, p. 266: W. F. Hume, *Geology of Egypt*, Vol. II, Part III, p. 862.
[2] Specimens from these sources may be seen in the Geological Museum, Cairo.
[3] O. H. Little, *Annales du Service*, XXXIII (1933), p. 80.
[4] W. M. F. Petrie, G. A. Wainwright and E. Mackay, *The Labyrinth, Gerzeh and Mazghuneh*, p. 22.
[5] D. Randall MacIver and A. C. Mace, *El Amrah and Abydos*, p. 49.
[6] A. Brongiart, *Cat. des Antiquités J. Passalacqua*, 1826, p. 223.
[7] W. M. F. Petrie, *Kahun, Gurob and Hawara*, p. 38.
[8] W. M. F. Petrie, *Nebesheh and Defenneh*, p. 75.

The former, or precious coral, is obtained mainly from the western Mediterranean and was an important article of commerce in Roman times. All the examples known from ancient Egypt are of late date, ranging chiefly from the Ptolemaic to the Coptic period and they consist either of amulets, or more generally, of beads or small branched pieces bored for suspension round the neck. Beads of this coral are common in the graves of late date recently discovered by Emery at Qustul, near Abu Simbel in Nubia.[1]

Pipe coral occurs on the shores of the Red Sea; Pococke saw it at Tor (Sinai[2]) and in the Geological Museum at Cairo there is a specimen from Dahab (East Sinai), but it is found also farther south.[3] This coral was known and used anciently, and beads of it, both of Badarian and early predynastic date, have been found[4] and also pieces broken up ready for threading[5]; it has been found, too, in a Nubian grave of about Old Kingdom date[6] and also in an Eighteenth Dynasty house at El Amarna.[7]

In addition to the specimens enumerated, other examples of coral are known, of which neither the kind nor colour are mentioned, for instance, a pierced branched piece of Badarian age[8]; a specimen of predynastic date[9]; a lump of 'fossil coral'[10]; a 'large piece,'[11] and one or two bits.[12] At Coptos both red and white coral were found.[13]

Green Felspar

Green felspar (microcline) or Amazon stone, as it is called sometimes, is an opaque pale green stone, not very uniform in colour, consisting

[1] W. B. Emery, *The Royal Tombs of Ballana and Qustul*, pp. 47, 53, 109, 111, 196, 202, 203, 205.

[2] R. Pococke, *A Description of the East and some other Countries*, p. 141.

[3] T. Barron and W. F. Hume, *op. cit.*, p. 137.

[4] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 38, 56. This material, which is now in the Cairo Museum, is organ coral and not dentalium as reported by the specialist to whom it was submitted by the finder: G. Brunton, *Mostagedda*, pp. 43, 51, 52, 71.

[5] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 21.

[6] G. A. Reisner, *Arch. Survey of Nubia, Report for 1907–1908*, p. 42. These beads are described as 'shell or coral' and the colour is not stated, but the late Mr. C. M. Firth informed the author that the material was pale red pipe coral.

[7] T. E. Peet and C. L. Woolley, *The City of Akhenaten*, I, p. 21.

[8] G. Brunton and G. Caton-Thompson, *op. cit.*, p. 35. [9] *Id.*, pp. 56, 63.

[10] G. Brunton, *Qau and Badari*, I, p. 26.

[11] A. C. Mace, *Egyptian Expedition, 1920–1921*, in *Bull. Met. Mus. of Art, New York*, II (1921), p. 12.

[12] E. Naville, *Deir El-Bahari*, III (1913), p. 18.

[13] W. M. F. Petrie, *Koptos*, p. 26.

of a double silicate of aluminium and potassium. Ball found small crystals at Gebel Migif in the eastern desert[1]; Robinson found ' a large perfect crystal in Wadi Abu Rusheid, a tributary of Wadi Nugrus '[2]; Ahmed Ibrahim Awad[3] found a broad seam of the blue-green variety, with ancient workings in Wadi Higelig about seven miles west of Gebel Migif, and numerous large lumps have been found on the lower slopes of the Hafafit range.

Green felspar was employed on a small scale for beads from as early as the neolithic period[4] and was much used in the Twelfth Dynasty, for example, in the jewellery from Dahshur and Lahun respectively, in the description of the former of which it is wrongly termed emerald. It was used also during the Empire, for instance, for amulets and inlay in the tomb of Tut-ankhamun.

Green felspar frequently is confused with other green stones and sometimes is called ' mother of emerald,' though it has no connexion whatever with emerald or beryl. Not infrequently this stone has a bluish tint and sometimes is definitely blue.

Fluorspar

One bead of green fluorspar and five beads of yellow fluorspar, of predynastic date, were found by Myers at Armant.[5]

Garnet

Garnet is the name applied to a group of minerals, consisting of double silicates of certain metals, that are distributed widely in nature, but generally are too dull for use as gem stones. The garnet employed by the ancient Egyptians was a dark red or reddish-brown translucent stone that occurs plentifully in the country, namely at Aswan, in the eastern desert[6] and in Sinai,[7] the stones, however, usually being too small for use, especially those from Aswan, the largest being those from western Sinai.[8] Garnet was used for beads as early as predynastic

[1] J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, p. 272.
[2] G. Robinson, in *Geology of Egypt*, W. F. Hume, Vol. II, Part III, p. 863.
[3] Geological Survey of Egypt.
[4] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 32, 40, 56, 87, 90.
[5] Sir R. Mond and O. H. Myers, *Cemeteries of Armant*, I, pp. 72, 84, 103, 104.
[6] T. Barron and W. F. Hume, *op. cit.*, pp. 170, 218: W. F. Hume, *Geology of Egypt*, Vol. II, Part III, pp. 863–4.
[7] T. Barron, *The Topog. and Geol. of the Peninsula of Sinai (Western Portion)*, p. 203.
[8] W. F. Hume, *Geology of Egypt*, Vol. II, Part III, 1937, pp. 863–4.

times.[1,2] Cailliaud, in 1821, says that at Aswan and at Elephantine he saw in the hands of 'the Arabs' perfectly crystallized garnets, one of which was an inch in diameter. He was unable to ascertain from where they had been obtained, but thought it could not be far away.[3]

Hæmatite

Hæmatite is an oxide of iron much used as an ore for the production of the metal: it occurs in different forms and colours and may be black, red, brown or foliated and micaceous. An earthy variety also occurs, but it will save confusion if this latter is called by the better name of red ochre. The particular hæmatite used by the ancient Egyptians for beads, amulets, *ḳohl* sticks and small ornaments was a black opaque kind with a metallic lustre, which was employed as early as the predynastic period.[4]

Although hæmatite occurs plentifully in Egypt and although it was worked in the eastern desert at a late period (probably Roman) for the production of metallic iron,[5] it is not known from where the small amount was obtained that was used earlier. Dioscorides says[6] that it was dug out of mines in Egypt. Several pieces of typical kidney-ore hæmatite were found by the Oriental Institute of Chicago in rubbish heaps in the temple of Medinet Habu.

Jade

The term jade includes two distinct minerals, nephrite or true jade and jadeite, which are so much alike that unless examined chemically or microscopically they cannot be distinguished with certainty from one another. Both may be coloured white, grey or various shades of green and both are translucent with a somewhat waxy or greasy lustre. The specific gravity and hardness also are much alike and may overlap, jadeite, however, being slightly the harder and heavier of the two. Chemically, the composition of the two materials is very different, nephrite being essentially a double silicate of calcium and magnesium and jadeite a double silicate of aluminium and sodium.

In the Old World nephrite occurs in the valley of the Kara Kash river in the Kwen Luen Mountains north of Kashmir and other

[1] W. M. F. Petrie, *Prehistoric Egypt*, p. 44.

[2] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 56.

[3] F. Cailliaud, *Voyage à l'oasis de Thèbes et dans les déserts*, pp. 12, 80; Pl. IX (7).

[4] W. M. F. Petrie, *op. cit.*, p. 43: E. R. Ayrton and W. L. S. Loat, *El Mahasna*, p. 11.

[5] See p. 274.

[6] v: 144.

localities in the neighbourhood, where there are ancient workings that are now almost exhausted; in Siberia, west of Lake Baikal and in small quantity in Silesia,[1] in Liguria,[1] in the Harz mountains[1] and possibly in other localities in Europe. Jadeite is found principally in Upper Burma, but also in China, Tibet and Brittany.[2]

Several specimens of what may be nephrite or jadeite have been found in Egypt, for example, two axe-heads of predynastic date, one of which is in the Cairo Museum[3] and the other in the Museum of University College, London, where there is also a heart scarab dated to the period Eighteenth to Twenty-second Dynasty and another of Nineteenth Dynasty date[4]; also a small axe-head discovered by Junker at the neolithic settlement of Merimde-Benisalame and now in the Cairo Museum, which the finder calls 'nephrit (chloromelanit)'[5]; a double signet ring found in the tomb of Tut-ankhamun[6] and several other objects stated to be possibly jade,[7] which latter in my opinion are neither nephrite nor jadeite. As it was impossible to examine any of these objects either chemically or microscopically without destroying them, the only determination that could be made was that of the specific gravity, which was done for the axe-heads and ring with the following results, namely, neolithic axe-head, 3.35; Cairo predynastic axe-head, 2.98; ring 3.04,[8] from which it seems possible that the neolithic axe-head may be jadeite, though it does not look like it, and the predynastic axe-head and ring may be nephrite. In my opinion, however, the identity of these objects is by no means yet certain and some, or all, of them may be amphiboles of the tremolite-actinolite group, which are found in the eastern desert of Egypt, for instance in Wadi Hafafit.[9] The ring is almost certainly nephrite, and that at the end of the Eighteenth Dynasty a small piece of this material should have reached Egypt from Asia would not be surprising.

[1] L. J. Spencer, *A Key to Precious Stones*, p. 211.

[2] C. Daryll Forde, *Journal Royal Anthrop. Inst.*, LX (1930), pp. 221–4.

[3] J. E. Quibell, *Archaic Objects*, No. 14259.

[4] W. M. F. Petrie, *Scarabs and Cylinders with Names*, pp. 8, 29; Pl. XLVIII.

[5] H. Junker, *Merimde-Benisaláme von 7. Februar bis 8. April 1930*, p. 80; Pl. VII. Cairo Museum, No. J. 57954.

[6] A. Lucas, *Appendix II*, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter, p. 182.

[7] J. E. Quibell, *op. cit.*, Nos. 14251, 14256–14258.

[8] A. Lucas, Appendix II, p. 182, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter, where the specific gravity is stated to be 3.4 instead of 3.04, which caused it to be classed as jadeite instead of nephrite, which it probably is.

[9] Kindly communicated by Mr. J. Dudler.

Jasper

Jasper is an impure, opaque, compact variety of silica, that may be coloured red, green, brown, black or yellow by compounds of iron, the red being the kind principally used in ancient Egypt, though the other colours were occasionally employed.

Red jasper was used chiefly for beads and amulets, though sometimes as inlay for jewellery, and occasionally for scarabs and other purposes, and parts of two shallow bowls of red jasper from the First Dynasty are known[1] and a large carved hand found at Medinet Habu is now in the Cairo Museum[2]; its use dates back to predynastic times.[3] Green jasper is known from as early as the Badarian period for an amulet and for a bead[4]; also for beads from the Fourth Dynasty[5] and from the Middle Kingdom for scarabs[6]: brown and black jasper date back to the Middle Kingdom, from which period there are several scarabs of these stones[6]: yellow jasper, so far as is known, was not used before the Eighteenth Dynasty, the best example being the well known broken head or face of Nofretiti: a part of a hand in yellow jasper found at Medinet Habu is now in the Cairo Museum.[7]

The recognition of red and yellow jaspers presents no difficulty, but in the case of green, brown and black jaspers mistakes of identification are not uncommon and statements about their use need verification before they can be accepted.

The jaspers of Egypt are well known and specimens of a brown jasper (sometimes banded) are exhibited in mineral collections in London, Vienna and Prague and possibly elsewhere. Red jasper occurs as bands in certain rocks in several localities in the eastern desert, for example in the neighbourhood of the Hadrabia hills[8]: near Wadi Saga[8] and in Wadi Abu Gerida,[8] in some of which places there is evidence of ancient mining: brown jasper is found plentifully in the form of pebbles: a large vein of green jasper spotted with red, which had been worked anciently, was seen by Bruce on his journey from Qena to Quseir[9]: whether black jasper is found naturally in Egypt

[1] J. E. Quibell, *Excavations at Saqqara (1912–1914)*, pp. 16, 17; Pl. XII. Mr. Quibell kindly showed me part of a second similar bowl.

[2] No. J 59740.

[3] R. Engelbach, *Harageh*, p. 14.

[4] G. Brunton, *Mostagedda*, pp. 38, 41, 51.

[5] G. Brunton, *Qau and Badari*, II, p. 20.

[6] W. M. F. Petrie, *Scarabs and Cylinders with Names*, p. 8.

[7] No. J 59793.

[8] T. Barron and W. F. Hume, *op. cit.*, pp. 52, 221, 228, 266: W. F. Hume, *Geology of Egypt*, Vol. II, Part III, p. 862.

[9] J. Bruce, *Travels to Discover the Source of the Nile*, II, 2nd ed., 1805, p. 89.

cannot be stated, but it probably is, though no record of its occurrence can be traced. A piece of worked jasper, partly red and partly yellow, was found by Myers at Armant, which proves that both colours occur naturally together, and since the red variety is Egyptian the yellow probably also is Egyptian. The red jasper hand already mentioned has also a small vein of yellow on the under side, and in the Cairo Museum there is also a beautiful small plaque of green and yellow jasper carved with a Hathor head in relief, probably of Saite date.

Lapis Lazuli

Lapis lazuli is an opaque stone of a dark blue colour with often spots, patches or veins of white (calcite) and sometimes minute yellow spangles of iron pyrites, looking like specks of gold: chemically, lapis lazuli consists of silicates of aluminium and sodium together with sodium sulphide: it is certainly the *sapphiros* of Theophrastus[1] and Pliny.[2]

So far as is known, lapis lazuli does not occur in Egypt, though several statements that it does occur have been made; thus MacIver says[3] that 'lapis lazuli is known to be native of Egypt,' but no evidence for this is given and the value of the statement is much discounted by the further statement that garnets are not found in Egypt, whereas they occur plentifully. Idrisi mentions[4] a mine of lapis lazuli near Kharga Oasis, but no confirmation can be obtained for any such occurrence and von Bissing states that lapis lazuli occurs in Abyssinia.[5]

The chief Old World source of lapis lazuli is Badakshan in the north-east corner of Afghanistan, but it also occurs near Lake Baikal in Siberia. The Badakshan mines are referred to by Marco Polo in the thirteenth century[6] and probably were the original source of the material. Although it is stated frequently that lapis lazuli was mined anciently in Persia, no confirmation of this can be obtained and the statement may be due to a confusion between lapis lazuli and turquoise, the latter of which does occur in that country, or to the fact that the lapis lazuli trade passed through Persia or was in the hands of Persian merchants.

[1] *History of Stones*, XLIII.
[2] XXXVII: 39.
[3] D. Randall MacIver and A. C. Mace, *El Amrah and Abydos*, pp. 48–9.
[4] *Geography*, French trans. by P. Amédée, I, Paris, 1836, p. 122.
[5] Fr. W. von Bissing, Probleme der ägyptischen Vorgeschichte, *Archiv für Orientforschung*, V (1928–29), p. 75 (n. 2 from p. 73).
[6] *The Travels of Marco Polo the Venetian*, p. 84 (Everyman's Library).

Lapis lazuli was used in ancient Egypt from predynastic times[1] onwards for beads, amulets, scarabs and other small objects as well as for inlay in jewellery, for which purpose it was employed extensively during both the Middle Kingdom and the Empire.

The use of lapis lazuli is mentioned frequently in the ancient Egyptian records, but so far as can be ascertained not earlier than the Twelfth Dynasty.[2] In the Eighteenth Dynasty lapis lazuli is stated to have been obtained from Assur,[3] Isy,[4] Retenu,[5] Shinar,[6] Syria[7] and Zahi[8] and in the Nineteenth Dynasty from God's Land[9] and Naharin,[10] all in western Asia. In both the Nineteenth[11] and Twentieth Dynasties[12] lapis lazuli of Tefrer, an unknown country, is mentioned. In a tomb, probably of early Middle Kingdom date, lapis lazuli from Tefroret is referred to.[13]

Malachite

Malachite is a copper ore of a fine green colour, a fractured surface of which often displays a beautiful and characteristic zonary structure, the successive layers showing strata of alternating light and dark tints: chemically it consists of hydrated (basic) carbonate of copper.

Although malachite is very common in ancient Egyptian graves of all periods from the Tasian, Badarian and predynastic to certainly as late as the Nineteenth Dynasty, the principal and almost the only forms in which it is found are that of powder (either loose or slightly cohering together) for use as an eye-paint, as lumps of the raw material from which the powder was made, or as stains on palettes and stones on which the powder was ground, and it is only very rarely indeed that malachite has been discovered either as worked objects or as inlay in jewellery. The few instances of this use of malachite that can be traced are as follows: a few large roughly made beads of predynastic date from Girga[14]; some beads from Ballas of the same period[15]; one

[1] W. M. F. Petrie, *Prehistoric Egypt*, p. 44. A tube of this material of predynastic date and unknown use mounted in gold is in the Cairo Museum (No. J. 31340) as also a small statuette of First Dynasty date.

[2] J. H. Breasted, *op. cit.*, I, 534, 667, 668. [3] II, 446.

[4] II, 493. [5] II, 447. [6] II, 484. [7] II, 509, 518, 536.

[8] II, 459, 462. [9] III, 116. [10] III, 434. [11] II, 448.

[12] IV, 30.

[13] A. H. Gardiner, The Tomb of a Much-Travelled Theban Official, *Journal of Egyptian Archaeology*, IV (1917), pp. 36–7.

[14] In the Cairo Museum, No. J. 44488.

[15] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 10.

or two small scorpions of the archaic period[1]; two pieces cut for ornament of the First Dynasty[2]; a few beads[3] and a tiny broken worked fragment from the Eighteenth Dynasty (the tomb of Tut-ankhamun); a small animal-shaped amulet of archaic form from the Nineteenth Dynasty[4]; a scarab[5] and two oval plaques[6] of unknown date.

Malachite has been confused frequently with other green stones, such as green turquoise, green felspar and even with beryl. Thus, although the necklace of Twelfth Dynasty date from Dahshur in the Cairo Museum, stated[7] to have lozenge-shaped plaques of malachite, cannot be identified with certainty, no necklace of any date with malachite on it can be found in the Museum. There are, however, two belts from Dahshur that answer to the general description of the necklace referred to, both of which have lozenge-shaped plaques, but in one case the green stone is green felspar and in the other it is turquoise. The beads in the collar and the stones in the bracelet, both of Graeco-Roman age, stated by Maspero[8] to be malachite and, in the case of the bracelet, also thought by Vernier[9] possibly to be malachite, are beryl, the bizarre shape of the stones commented upon by Vernier being simply the natural hexagonal form of the beryl crystal as found, the Egyptians apparently not having any means of cutting this stone, which is slightly harder than quartz, until a very late date, though they were able to bore it.

Malachite occurs in Sinai and in the eastern desert of Egypt, from both of which places it was obtained anciently, at first probably merely from surface outcrops for use as an eye-paint and later by mining for the production of copper.

From two of the same localities in Sinai where copper ore occurs, namely Maghara and Serabit el Khadim, turquoise was obtained also anciently[10] and this occurrence in the same place of two different materials, one (malachite) green and the other (turquoise), though often blue, frequently greenish-blue or even definitely green, has given rise

[1] J. E. Quibell and W. F. Green, *Hierakonpolis*, II, p. 38. In *Hierakonpolis*, I, Petrie says (p. 8) that one of the scorpions is of black hæmatite.

[2] W. M. F. Petrie, *The Royal Tombs*, II, p. 37; Pl. XXXV.

[3] A. Lucas, in *The Tomb of Tut-ankh-Amen*, H. Carter, II, Appendix II, p. 185.

[4] The Egyptian Exploration Society, *Catalogue of Exhibits*, 1926, p. 12. Examined by me.

[5] W. M. F. Petrie, *Scarabs and Cylinders with Names*, p. 8.

[6] Cairo Museum No. $\frac{1\,7}{6\,2}|\frac{1\,2}{8\text{-}9}$.

[7] G. Maspero, *Guide to the Cairo Museum*, English trans., 1903, p. 511.

[8] G. Maspero, *op. cit.*, p. 527.

[9] E. Vernier, *op. cit.*, p. 64, No. 52151, Pl. XVI.

[10] See pp. 231–2.

to considerable confusion, so much so that malachite has been termed turquoise matrix, though the two materials are totally different in composition and have no connexion with one another. It has resulted also in the ancient Egyptian name for turquoise (*mafkat*) being translated sometimes as malachite,[1] which if accepted, would mean that malachite was associated with silver, gold and costly stones, particularly lapis lazuli, and was used plentifully for finger rings, collars, inlay and scarabs and that there is no mention in the ancient Egyptian records of turquoise, whereas the Egyptian objects in the various museums prove the contrary, namely, that it was turquoise that was largely used in jewellery (particularly with lapis lazuli), for inlay and for scarabs and not malachite, which was very rarely employed as a gem stone. The ancient Egyptian name for malachite was *shesmet*.

Pearl

Pearls are calcareous concretions of peculiar and characteristic lustre produced by various molluscs, chiefly, however, by the pearl-oyster and the pearl-mussel, the former of which is found on the Red Sea coast of Egypt, as well as in the Persian Gulf, off the coast of Ceylon and in other localities.

Although mother-of-pearl was used in Egypt from predynastic times, the pearl was not employed until the Ptolemaic period. To this only one exception is known to me and that not of true pearls, namely the button pearls in the necklace of Queen Ah-hotpe, mother of King Amosis, of the beginning of the Eighteenth Dynasty.[2]

Olivine, Peridot

Olivine is a compound silicate of magnesium and iron: it is transparent or translucent and usually of a pale green colour: it was employed in Egypt as early as predynastic times for beads.[3, 4, 5, 6] As already stated[7] some and probably most of the beads and other objects found in Nubia termed beryl are olivine.

Peridot, a transparent pale green stone, is merely the gem form of olivine; it is found on St. John's Island in the Red Sea and is probably

[1] J. H. Breasted, *op. cit.*, v (Index), p. 143.

[2] A. Lucas, *The Necklace of Queen Aahhotep*, in *Annales du Service*, XXVII (1927), pp. 69–71.

[3] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 44.

[4] In describing certain objects from Abydos, Petrie says (*The Royal Tombs*, II, p. 37) 'a piece of the clear green serpentine which is frequent in prehistoric work.'

[5] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 56.

[6] G. Brunton, *Mostagedda*, p. 86. Also G. Brunton, *Matmar* (in the press).

[7] See p. 447.

the stone that Strabo[1] and Pliny[2] call *topazos*, as both writers state that this was obtained from such a locality. Strabo refers to the golden lustre of the stone, but Pliny states that it was leek-green and mentions its softness compared to other gem stones.

The only example of the use of peridot in ancient Egypt of which any record can be found is that of a scarab of the Eighteenth Dynasty.[3]

Quartz, Rock Crystal

Quartz is a crystalline form of silica which when pure is colourless and transparent, but which may be translucent or opaque. The former is termed rock crystal and the latter milky or cloudy quartz, the milkiness being due to multitudes of small air cavities. Sometimes quartz is coloured from light brown to almost black and is then termed smoky quartz, which particular kind has been found in an ancient gold mine at Romit in the eastern desert,[4] or it may be amethyst-coloured in patches, when it is termed amethystine quartz, one occurrence of which is in the same locality as the Chephren diorite quarry, namely about forty miles north-west of Abu Simbel.

Quartz occurs abundantly as veins in igneous rocks in the eastern desert[5] and at Aswan,[6] at which latter place an outcrop of quartz is shown to tourists as alabaster. This has been worked anciently to some extent and a few blocks of it may be seen at the north end of the island of Philae.[6] Quartz crystals (rock crystal) are found in geodes in limestone in the district stretching from the Fayum to Baharia Oasis and as pebbles derived from such geodes, and also in Sinai.

Rock crystal was employed in ancient Egypt in small amount from predynastic times onwards,[7] being fashioned into beads and other objects including small vases and the cornea of eyes in statues and on coffins. In the Eighteenth Dynasty, as already mentioned,[8] it was employed as inlay, being set in red cement to imitate carnelian and in this same dynasty the handle of the iron dagger from the tomb of Tut-ankhamun is ornamented with a finely-worked knob of rock crystal,[9] which, however, is probably not of Egyptian origin.

[1] XVI: 4, 6. [2] VI: 34; XXXVII: 32.
[3] W. M. F. Petrie, *Scarabs and Cylinders with Names*, p. 8.
[4] J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, p. 353.
[5] T. Barron and W. F. Hume, *op. cit.*, pp. 218, 221: W. F. Hume, *Geology of Egypt*, Vol. II, Part II, pp. 584–7.
[6] J. Ball, *The Aswan Cataract*, p. 84.
[7] W. M. F. Petrie, *Prehistoric Egypt*, p. 44. [8] See p. 448.
[9] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 135.

Amethystine quartz was employed occasionally in the early dynastic period for making small vases. In the Cairo Museum there are a number of large implements of opaque quartz (possibly of paleolithic date) from Aswan and fifteen smaller implements[1]; also a number of small triangular-shaped implements[2] and a broken implement with serrated edges[3] of clear rock crystal, all of early date.

All varieties of quartz are much harder than glass, which they scratch easily, and they are also harder than steel, and, therefore, they cannot be marked with a file.

Turquoise

Turquoise consists of hydrated phosphate of aluminium coloured by means of a trace of a copper compound; it is never crystalline, but occurs in opaque amorphous masses filling veins in the mother rock. The typical colour is a delicate sky-blue, though many stones are greenish-blue and others definitely green.

The source of turquoise employed in ancient Egypt was undoubtedly Sinai at Wadi Maghara and Serabit el Khadim, in both of which places there are ancient workings, the former of which are exploited still unsystematically and intermittently by the local bedouin.[4, 5, 6, 7] The turquoise occurs in seams in a sandstone rock. Another ancient and well known source of turquoise was Persia.

Turquoise has been known and used in Egypt from as early as the neolithic,[8] Badarian[9] and predynastic[10] periods respectively: its authenticity has been doubted in the case of several bracelets of First Dynasty date from Abydos[11] in which it is present and it has been thought to be glass,[12] though it is undoubtedly turquoise as originally described by the finder, much of it, however, being green and not blue: it was employed as inlay in a number of anklets found by Reisner in the Fourth Dynasty tomb of Hetepheres at Giza, where it was at first

[1] Nos. J. 67414–67428. [2] Nos. J. 56607–56623. [3] No. J. 57176.

[4] Mines and Quarries Department, *Report on the Mineral Industry of Egypt*, 1922, p. 38.

[5] J. Ball, *The Geog. and Geol. of West-Central Sinai*, pp. 11, 163.

[6] T. Barron, *The Topog. and Geol. of the Peninsula of Sinai (Western Portion)*, pp. 209–12.

[7] G. W. Murray, *The Hamada Country*, in *Cairo, Sci. Journ.*, VI (1912), pp. 264–73.

[8] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 53, 56, 87, 90.

[9] G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 27, 41, 56. See p. 240, *n.* 3.

[10] W. M. F. Petrie, *Prehistoric Egypt*, p. 44: G. Brunton, *Mostagedda*, pp. 71, 86.

[11] W. M. F. Petrie, *The Royal Tombs of the Earliest Dynasties*, II, pp. 17–9.

[12] E. Vernier, *op. cit.*, pp. 10–1, 13–4.

described as malachite[1]: it occurs plentifully in the Twelfth Dynasty jewellery from Dahshur, where some examples have been thought to be artificial on account of their excellent colour[2]: it is also present in small amount in the jewellery from the tomb of Tut-ankhamun, namely as a scarab of a good blue colour and as greenish-blue inlay on two pectorals.

As already pointed out,[3] Breasted's translation of the ancient Egyptian records makes no mention whatever of turquoise, which, considering the extensive and early use of this material, is remarkable and is due to the ancient Egyptian word for turquoise (*mafkat*)[4, 5] having been translated wrongly malachite.

[1] See note 9, p. 279.
[2] E. Vernier, *op. cit.*, pp. 88, 298, 299, 307, 336.
[3] See p. 458. [4] A. H. Gardiner, *Egyptian Grammar*, p. 543.
[5] V. Loret, *La turquoise chez les anciens Égyptiens*, in *Kêmi*, 1 (1928), pp. 99–114.

CHAPTER XVII

STONES OTHER THAN BUILDING STONES AND PRECIOUS STONES: STONE VESSELS

Certain stones have already been discussed in connexion with building materials, but stone was employed in ancient Egypt, not only for building, but also for obelisks, sarcophagi, statues and other monuments, as well as for smaller objects, such as statuettes, bowls, vases, tools and weapons and the earliest objects that have survived to the present day in Egypt, as in many other countries, are of stone (chiefly flint). The stones employed, excluding precious and semi-precious stones, which have been dealt with separately, comprise alabaster, anhydrite, basalt, breccia, chert, diorite, dolerite, dolomite, flint, granite, gypsum, limestone, marble, obsidian, porphyry and porphyritic rocks, quartz, quartzite, rock crystal, sandstone, 'schist' (greywacke, tuff and volcanic ash), serpentine, slate and steatite, and few countries possess such a variety of stones as Egypt, many of them being very handsome when cut and polished.

There are few subjects in Egyptology that are so full of confusion, and even of contradiction, as that of the nomenclature of the various kinds of stone employed by the ancient Egyptians and I propose to try and unravel the tangle to at least some extent. It is realised that in any scheme of classification there must be difficulties and anomalies and that it is practically impossible to frame definitions that will be satisfactory from every point of view, and the final court of appeal must of course be the petrologist, but it is thought that guided by a few broad principles, with which it is hoped every one will be in agreement, the matter may be much simplified. The principles are, first, that for the purposes of Egyptology any highly technical description of the various rocks is unnecessary and that general features and broad characteristics alone need be taken into account, and hence that many of the finer distinctions of the geologist may be disregarded, and second, that old names that are well rooted in the literature of Egyptology should be retained whenever possible, unless seriously wrong, though the better and more scientific name should also be given.

Alabaster

The nature and occurrence of alabaster have already been dealt with in connexion with its use as a building material[1] and, therefore, need not again be discussed. This stone was always a favourite with the ancient Egyptians, doubtless partly owing to the fact that it not only looked well and took a good polish, but also because, being a soft stone, it was easy to work.

In addition to its employment as a building material, alabaster was used for many other purposes, and objects of this stone are known that range in date from predynastic times to a very late period, one of its commonest and earliest uses being for making vases and another early, but occasional, use being for mace-heads; it was also employed for sarcophagi (for example those of Hetepheres and Seti I respectively), canopic boxes, canopic jars, statues, statuettes, offering-tables, bowls, dishes and other objects.

Basalt

Basalt and its occurrence in Egypt have been treated in relation to its use as a building material[2] and, therefore, need not further be described; but long before it was employed for building and despite its hardness and the consequent difficulty of working it, this stone was used for making vases, some of which date back to neolithic times[3] and others to the Badarian[4] and predynastic[4, 5] periods respectively. Axe-heads of basalt of neolithic date are also known.[6]

One occasional use of basalt in the early dynastic period was for sarcophagi (though not every sarcophagus called basalt is basalt), for example the sarcophagus found by Vyse in the pyramid of Mycerinus (which was lost at sea on its way to England, but of which a small piece was sent to the British Museum[7]) is stated to have been of basalt,[7] though 'the brittle quality of the stone'[8] referred to by Vyse is not easy to understand. A small piece of stone exhibited at the British Museum with the wooden coffin from the pyramid of Mycerinus, as seen through the glass of the case appears to be basalt, and this may

[1] See p. 75. [2] See p. 77.
[3] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 72, 138.
[4] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 5, 7, 28, 41, 57.
[5] See p. 481.
[6] G. Caton-Thompson and E. W. Gardner, *op. cit.*, pp. 26, 38, 81, 84–7, 138.
[7] H. Vyse, *The Pyramids of Gizeh*, II, p. 84, and *n.* 4.
[8] H. Vyse, *op. cit.*, I, p. xviii.

be the piece referred to, though pieces of two different sarcophagi, both called basalt, were sent by Vyse to the British Museum.[1] Of the sarcophagi stated by Vyse to be basalt, one, at least, is certainly not basalt, but light blue-grey 'schist.' Thus he found a number of sarcophagi in Campbell's tomb at Giza, three of which he calls basalt,[2] and in the British Museum (No. 1384) there is a blue-grey 'schist' sarcophagus labelled 'Grey basalt coffin of Wah-Ab-Ra' and stated to be of the Twenty-sixth Dynasty from Campbell's tomb, which is almost certainly one of these.

In addition to the use of basalt for sarcophagi it was also occasionally employed for statues, though on account of the frequent confusion of basalt with dark-grey granite, black granite and 'schist,' objects frequently have been called basalt that are not basalt.

Breccia

Breccia is composed of angular fragments of one or more kinds of rock embedded in a matrix of another material, the characteristic feature being that the included fragments are sharp-edged and unworn, as distinguished from the worn and rounded fragments of a conglomerate. The name breccia, therefore, denotes the structure of the rock and not its composition. A number of different breccias occur in Egypt and were used anciently, of which two may be mentioned specially, namely, a red and white variety and a green variety.

The red and white breccia is calcareous and consists of white fragments embedded in a red matrix; it is found abundantly on the west bank of the Nile in several localities, for instance, north of Minia,[3] near Asiut,[3] at Thebes[3] and near Esna[3] and it also occurs in the eastern desert.[4] This stone was used in predynastic and early dynastic times chiefly for vases and apparently not again until the Romans worked it for exportation to Italy.

The green breccia consists of fragments of rocks of the most varied description embedded in a matrix, which is variable in colour with green predominating; it is, however, not a typical breccia, as while some of the fragments are angular, others are rounded, and it is sometimes called a brecciated conglomerate; but since in the past it has

[1] H. Vyse, *op. cit.*, I, pp. 214–5, *n.* 3.

[2] One found under the red granite sarcophagus Y; one marked X and one marked B. (H. Vyse, *op. cit.*, II, pp. 131, 132; Figs. 2 and 3.)

[3] W. F. Hume, *Explan. Notes to Geol. Map of Egypt*, p. 46.

[4] T. Barron and W. F. Hume, *The Topog and Geol. of the Eastern Desert of Egypt, Central Portion*, p. 171

always been termed breccia and was the *breccia verde antico* of the Romans, it is much better to retain the old name.

This green breccia is found in several localities, the best known of which is the Wadi Hammamat in the eastern desert on the Qena-Quseir road,[1, 2] where it occurs extensively and where it was worked anciently, though so far as is known, not until a very late period; it is not, however, the typical rock of the Wadi, as is often stated, this being schist. Green breccia occurs too at the mouth of the Wadi Dib[1]; in the region to the west of Gebel Dara and Gebel Mongul in the El Urf chain[1] and at Gebel Hamata,[3] all of which are situated in the eastern desert, and also in Sinai.[4]

The green breccia of the Wadi Hammamat was used occasionally in Egypt at a late period, but it was quarried chiefly by the Romans for export to Italy. The principal and probably the only objects of this breccia in the Cairo Museum are parts of a broken sarcophagus of Nectanebo II (Thirtieth Dynasty) and in the British Museum there is a similar sarcophagus of Nectanebo I. Legrain described[5] a number of statues from Karnak as being of green breccia, but those that the author has been able to examine are not green breccia.

Fragments of breccia of foreign origin, probably from Greece, have been found in excavations at Alexandria.

Diorite

Diorite is the name of a family of crystalline, granular rocks consisting essentially of felspar (white) and hornblende (black or dark green), which may be either fine-grained or coarse-grained. It occurs extensively in Egypt in several localities, namely, near Aswan, in the eastern and western deserts and in Sinai.

The use of diorite in Egypt goes back to neolithic times, from which period there is a broken object (possibly part of a palette) and an axe-head.[6]

The diorite employed anciently was of several different kinds. One of these, a coarse-grained black and white speckled rock in which the component minerals (white felspar and black hornblende) are fairly

[1] T. Barron and W. F. Hume, *op. cit.*, p. 263.
[2] W. F. Hume, *Geology of Egypt*, II (Part I), pp. 256–60.
[3] J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, p. 351.
[4] W. F. Hume, *Explan. Notes to Geol. Map of Egypt*, p. 49.
[5] G. Legrain, *Statues et Statuettes*, I, pp. 1, 41; II, pp. 3, 36, 89, 98.
[6] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 32, 33, 40, 87.

evenly distributed, was used in predynastic and early dynastic times for maceheads, bowls and vases and occasionally for palettes. This particular variety was probably obtained from Aswan, where an identical rock is known to occur[1] and where another rock, granite, was being worked at an early date and, although a similar diorite is largely developed in the eastern desert in the hills north of the Qena-Quseir road and was worked in Wadi Semna (north-west of Quseir) by the Romans,[2] there is not any evidence of earlier working.

Another kind of rock that is called diorite by archaeologists (the name being well rooted in the literature) is that of which the well known statue of Chephren in the Cairo Museum is made, the use of which is not known before the early dynastic period and is principally confined to the Old Kingdom. This rock, which is banded, or mottled, black and white, varies considerably in appearance, even in different parts of the same block, and the general effect may be dark grey, light grey or white slightly flecked with black, the last-named variant having been much employed for making bowls and vases, the other varieties having been used for statues, especially during the Fourth Dynasty.

Some years ago, I suggested[3] that, since this rock has a gneissic structure, a suitable name for it would be diorite-gneiss, which would indicate both its composition and structure, and Mr. O. H. Little, Director of the Geological Survey of Egypt, in a recent description of it states,[4] 'If diorite-gneiss were substituted for diorite, it would be more correct, though the term is not applicable to all varieties.' Anorthosite-gneiss would be still better.[5]

In the past there has been much speculation respecting the locality from which this particular diorite-gneiss was obtained, which was unknown until very recently, when the source was discovered in the western desert about 40 miles north-west of Abu-Simbel in Nubia.[6, 7]

[1] J. Ball, *The Aswan Cataract*, Pl. V (2).

[2] T. Barron and W. F. Hume, *The Topog. and Geol. of the Eastern Desert of Egypt*, pp. 221, 265.

[3] A. Lucas, *Ancient Egyptian Materials*, first edition, 1926, p. 181.

[4] O. H. Little, *Prelim. Report on some Geol. Specimens from the 'Chephren Diorite' Quarries, Western Desert*, in *Annales du Service*, XXXIII (1933), pp. 75–80.

[5] W. F. Hume, *Geology of Egypt*, II, Part III, p. 867, Pl. CXCIV*a*. This term is also used by Andrew, Sudan Government geologist.

[6] R. Engelbach, *The Quarries of the Western Nubian Desert*, in *Annales du Service*, XXXIII (1933), pp. 65–74. Also *Annales du Service*, XXXVIII (1938), pp. 369–90.

[7] W. F. Hume, *Geology of Egypt*, II (Part I), pp. 299–300. G. W. Murray, The Road to Chephren's Quarries, *Geog. Journal*, 94 (1939), pp. 97–111.

It is only a special variety, possibly, however, unique, of the diorite that occurs in other localities.[1] Another variety of diorite (porphyritic-diorite), composed of a compact black matrix in which are embedded conspicuous white fragments, will be considered when dealing with porphyry.

Engelbach points out[2] that on a block of ' almost black diorite ' this Chephren stone apparently is termed *mntt* stone, a name that is used also on a statuette of dark grey granite with large crystals of pink felspar.

Dolerite

As already explained,[3] dolerite is merely a coarse-grained basalt and there is no fundamental difference and no hard and fast line of demarcation between the two.

Dolerite occurs in several localities in the eastern desert of Egypt, namely, in the neighbourhood of Wadi Esh near Quseir[4]; in Wadi Atolla, a little south of Wadi Esh, where in one place the rock is marked with a cartouche of Ramesses III (Twentieth Dynasty)[5] and near Gebel Dokhan, where there are ancient quarries probably of Roman date[6]; it is also found in Sinai.

One important use of dolerite in ancient Egypt was for pounders for working hard stone, and roughly spherical specimens of this rock may still be seen in large numbers in the ancient granite quarries at Aswan and in the quartzite quarry at Gebel Ahmar near Cairo, where they have remained since they were employed by the ancient quarrymen. Spherical masses of dolerite, resembling these pounders, occur naturally in certain places in the cataract regions of the Nile and in the eastern desert.[7]

Dolomite

Dolomite is a definite compound (and not merely a mixture) of calcium carbonate and magnesium carbonate in the proportion of 54.4 per cent of the former and 45.6 per cent of the latter. Magnesium carbonate is a very common constituent of limestone, but is usually

[1] G. Andrew, Note on the ' Chephren Diorite,' *Bull. de l'Inst. d'Égypte*, XVI (1933–4), pp. 105–9.
[2] R. Engelbach, *Annales du Service*, XXXIII (1933), p. 66.
[3] See p. 77.
[4] T. Barron and W. F. Hulme, *op. cit.*, pp. 52, 236.
[5] *Id.*, pp. 217, 263. [6] *Id.*, pp. 26, 236.
[7] W. F. Hume, *Preliminary Report on the Geology of the Eastern Desert*, p. 49.

present in very small proportions, thus out of 132 specimens of limestone from the neighbourhood of Cairo analysed by me all contained magnesium carbonate, but only 15 contained more than 5 per cent and only two contained more than 20 per cent, the proportion of magnesium carbonate in these being 30 per cent and 37 per cent respectively. When the proportion of magnesium carbonate is substantial, as in the two cases mentioned, but not sufficient to form dolomite, the rock is termed dolomitic limestone (or magnesian limestone) and, since dolomite and dolomitic limestone are so much alike that they cannot be distinguished except by chemical analysis, they are usually classed together.

Both dolomite and dolomitic limestone were employed in ancient Egypt in early dynastic times for bowls and vases and probably occasionally at later periods for other objects. Petrie reports 44 vases of what he terms 'dolomite marble' from the First Dynasty[1, 2] and I have analysed the material of a number of broken vases of Third Dynasty date from Saqqara, some of which were dolomite or practically dolomite and others dolomitic limestone.

Petrie, describing the 'dolomite marble,' says[3]: 'This material varies much, but cannot be confounded with any other class. It is hard, opaque, white with veins; sometimes the veining is of clearer white, but usually of grey and sometimes of quartz, almost black. The magnesia of the dolomite is left on the surface as a powdery white incrustation, if it has been exposed to solution by weathering.'

The specimens examined by me have all been white with veins or patches of dark grey; the surface has always been dull, though probably it was polished originally; the white has been chalky in appearance and a fine white powder has rubbed off when the specimens have been handled. The characteristic appearance of this stone, together with the fact that cold dilute hydrochloric acid causes little or no effervescence, makes it easy to identify. Dolomite occurs in the eastern desert in several localities.[4]

Flint, Chert

The stone first used in Egypt, as in many other countries, was flint, and from it, before metal was known, Stone Age man fashioned his

[1] W. M. F. Petrie, *The Royal Tombs*, II, p. 41, Pls. IX (2–10); LI (c, d, e).
[2] W. M. F. Petrie, *Abydos*, I, p. 7; Pl. IX (5, 6, 7, 10).
[3] W. M. F. Petrie, *The Royal Tambs*, II, p. 44.
[4] W. F. Hume, *Geology of Egypt*, II (Part 1), pp. 89, 144, 160.

weapons and tools and even long after copper was generally employed, the use of flint, although it naturally decreased considerably, did not entirely cease, but continued for certain purposes, some of which were purely ceremonial. The manufacture and use of flint knives is shown in tomb paintings of Twelfth Dynasty date at Beni Hasan,[1] when manifestly it was still a living industry. A very large number of flint implements (knives and scrapers) and also sickle flints were found by Emery in a First Dynasty tomb at Saqqara.[2]

Flint was also used at an early date for personal ornaments, chiefly bracelets, and occasionally even for bowls, one such of Second Dynasty date having been found in the Fourth Dynasty temple of Mycerinus.[3]

Flint consists of a very compact form of silica; it is dark grey or black in colour; breaks with a conchoidal fracture and affords sharp cutting edges; it occurs plentifully in certain districts in Egypt in the form of nodules and layers in the limestone rock and in such localities it is also found scattered about the surface of the desert, having been freed by the weathering of the limestone.

Chert is an impure kind of flint of a light grey or light brown colour and, although it is largely composed of silica, it breaks with a more or less flat fracture instead of the conchoidal fracture of flint; it occurs like flint in limestone and was sometimes used in place of flint.

Granite

Granite and its occurrence have already been described in connexion with building materials,[4] where it was stated to be the name of a large class of crystalline rocks of igneous origin, the individual minerals of which, chiefly felspar, quartz and mica, are sufficiently large to be visible to the naked eye. The typical granite of ancient Egypt is the coarse-grained red variety that forms the greater part of the hills between Aswan and Shellal. This is a true granite and its recognition presents no difficulty and leaves no room for doubt or confusion. Granite, however, being a natural material is not uniform in structure, composition or even colour, but varies considerably in all three respects, thus the grain of the rock may be coarse or fine, the relative proportion or distribution of the contained minerals may vary and the felspar may be red, white or occasionally green, the rock in the first case being

[1] P. E. Newberry, *Beni Hasan*, I, p. 31; Pl. XI; II, p. 47; Pl. IV: F. Ll. Griffith, *Beni Hasan*, III, pp. 33–8; Pls. VII, VIII, IX, X.

[2] W. B. Emery, *The Tomb of Hemaka*, pp. 18–27, 33.

[3] G. A. Reisner, *Mycerinus*, p. 102.

[4] See p. 72.

coloured red, in the second case, black and white or light grey, or when the darker minerals (mica and hornblende) preponderate, dark grey or even practically black and in the third case green. Granite, too, merges into rocks of other types without any hard and fast line of demarcation.

The geologist divides granite into a number of sub-classes in accordance with their composition, but with these divisions Egyptology is not concerned, all that is required being a broad classification, subtle distinctions being quite unnecessary. Thus the geologist's hornblende-biotite-granite may reasonably be called dark grey or black granite, as the case may be, by the archaeologist. There will probably be some difference of opinion as to the degree of elasticity that may be allowed in calling stone granite, or in other stone nomenclature, but for the purposes of Egyptology the boundaries should be as wide as possible.

Granite was employed in predynastic times, though only sparingly and chiefly for bowls and vases, but in the early dynastic period it was worked to a much greater extent on account of the increased use of copper tools and, in addition to its use as a building material, it was also employed for sarcophagi, and at later periods for statues, obelisks, stelæ and other objects.

The occurrence of granite in Egypt has already been described[1] in connexion with its use for building purposes.

Gypsum, Anhydrite

Gypsum, as already explained when dealing with plaster,[2] although often occurring in scattered masses of loosely aggregated crystals, quite useless for carving, is also found in compact rock-like formation, for example in the Mariout region to the west of Alexandria; between Ismailia and Suez; in the Fayum and very plentifully near the Red Sea coast.

Gypsum consists of hydrated calcium sulphate and in appearance it much resembles alabaster (calcite), which is calcium carbonate, and it is often called alabaster and even claims, probably wrongly, priority for the name.

Apart from its use for mortar and plaster, gypsum was employed only to a comparatively small extent in ancient Egypt. Miss Caton-Thompson has shown that a very large number of gypsum vases and dishes were made in the Fayum during the Third Dynasty[3] and Petrie

[1] See p. 74. [2] See p. 97.
[3] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 105–7.

found at Giza[1] several intact and many broken gypsum vases of Second or Third Dynasty date that probably came from the Fayum factory. Among the objects from the tomb of Tut-ankhamun two of the knobs on the saddles of the chariot harness are gypsum, the others that have been tested by me being alabaster (calcite).[2] Petrie found a gypsum dish[3] of proto-dynastic date and a few gypsum boxes of Roman date.[4] Myers found a gypsum vase of predynastic date at Armant.[5]

Until recently a pale blue material used chiefly in the Middle Kingdom for small vases was assumed to be marble on account of its appearance and has always been called 'blue marble,'[6] but a doubt about the identity of the material having been raised Mr. O. H. Little, Director of the Geological Survey of Egypt, determined the specific gravity of a fragment and found that it was not marble, but anhydrous calcium sulphate (anhydrite), and I made a chemical analysis with the same result. The source of this material is not known, but it is most probably local. Petrie suggests, without any evidence whatever, that it 'seems to have been brought from the north of the Mediterranean,'[7] and again 'The bluish marble of the Aegean is found in many examples there' (at Kahun).

Gypsum is softer than alabaster (calcite) and may be scratched with the finger-nail, whereas alabaster cannot be scratched with anything softer than steel. The anhydrous form of calcium sulphate (anhydrite) is about the same hardness as calcite.

Limestone

Limestone has already been dealt with in connexion with building materials.[8] In addition to this use, however, it was largely employed for other purposes, including vases, and it was one of the first stones used, except for weapons and tools, because it was soft and easily worked and also because it lent itself admirably to carving on account of its fine texture; its use dates back to neolithic times. The wide distribution of limestone in Egypt has already been mentioned.

[1] W. M. F. Petrie, *Gizeh and Rifeh*, p. 7.
[2] A. Lucas, *Appendix II*, p. 168, in *The Tomb of Tut-ankh-Amen*, II, Howard Carter.
[3] W. M. F. Petrie, *Prehistoric Egypt*, p. 36.
[4] W. M. F. Petrie, *Hyksos and Israelite Cities*, p. 58; Pl. XLIII (24–31).
[5] Sir R. Mond and O. H. Myers, *Cemeteries of Armant*, I, p. 36.
[6] See also J. Garstang, *El Arabah*, 1901, pp. 28–9.
[7] W. M. F. Petrie, *Kahun, Gurob and Hawara*, pp. 30, 42.
[8] See p. 66.

Black crystalline limestone was used occasionally during the predynastic period for vessels, such a limestone occurring in the eastern desert[1] and in the Cairo-Suez district.[2] A hard fine-grained yellow limestone also was sometimes used and a similar stone occurs behind Gebel el Geir east of Qift[3] and also between Kharga Oasis and the Nile.[4] A pink limestone occurs plentifully in Egypt, particularly in the western desert on the Edfu-Dush road and on the Asiut-Kharga road and also between Ismailia and Suez, and was used occasionally.

nite

Marb' .

Marble is a crystalline form of limestone having a compact structure that enables it to take a high polish; it is usually white or grey, but may be of almost any colour and is often veined in different colours.

The known occurrences of marble in Egypt are chiefly confined to the eastern desert, where it is recorded from several localities,[5, 6, 7] namely, a grey saccharine-looking variety from Wadi Dib (west of Gebel Zeit and fairly close to the Red Sea coast) and both a white and a colourless kind from Gebel Rokham (near the upper part of Wadi Miah, east of Esna and roughly two-thirds of the way between the Nile and the Red Sea), the latter of which was exploited to a small extent in Arab times[8] and possibly earlier; a third occurrence is in the far south-eastern desert[9]; a hard crystalline limestone, practically marble, occurs at Beni Sha'ran opposite Manfalut, and recently a yellowish-grey, very nummulitic marble with brown patches has been discovered at Geran el Ful on the northern edge of the plateau to the west of the Giza pyramids. This, however, was not used and was probably not known anciently. From where the comparatively small amount of marble employed anciently was obtained is not known.

Marble was used to a small extent for vases in predynastic and early dynastic times; it was used for statues during the Eighteenth and Nineteenth Dynasties (examples: a beautiful small statue of Tuthmosis III in white marble slightly veined in grey, now in the Cairo

[1] W. F. Hume, *Geology of Egypt*, II, Part I, pp. 201, 203.
[2] T. Barron, *Cairo-Suez District*, pp. 27, 99, 100, 101.
[3] Information kindly supplied by Mr. J. Dudler.
[4] W. F. Hume, *Geology of Egypt*, I, p. 134.
[5] W. F. Hume, *Explan. Notes to the Geol. Map of Egypt*, p. 47.
[6] T. Barron and W. F. Hume, *The Topog. and Geol. of the Eastern Desert of Egypt*, pp. 32, 119, 240, 266–7.
[7] W. F. Hume, *Geology of Egypt*, II (Part I), pp. 101, 171, 172.
[8] J. Barthoux, *Mém. de l'Inst. d'Égypte*, V (1922), p. 33.
[9] J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, pp. 348–9.

Museum,[1] and a number of large statues in the temples at Luxor and Karnak respectively and several in the Cairo Museum) and it was employed for statues and portrait heads in Roman times, numerous examples of which are in the Museums at Cairo and Alexandria. Fragments of foreign marble from Greece have been found in excavations at Alexandria.

Pliny mentions[2] 'marbles of Alexandria,' the Augustan and Tiberian, which were discovered in Egypt in the reigns of the emperors Augustus and Tiberius respectively. The stones, he explains, differ 'in the arrangement of their spots,' one having them 'undulated and curling to a point,' whereas in the other 'the streaks are white, not involved, but lying wide asunder.'

This same writer also mentions[2] a third kind of marble called '*memphites*' after Memphis, where it was found, which he says was 'of a nature somewhat analagous to the precious stones.' Whether all, or any, of these stones were marble in the modern sense is uncertain, though if *memphites* were indeed obtained from near Memphis, it was probably some sort of limestone, since no other kind of stone is known to occur in that locality.

The so-called 'blue marble,' used principally in the Middle Kingdom for making small vases, as already stated,[3] is not marble but anhydrite.

Obsidian

Obsidian is a glassy-looking material that breaks with the conchoidal fracture of glass and is a natural glass of volcanic origin; the colour is usually black, but may be brown, grey or green; in thin sections it is translucent.

So far as is known obsidian is not found naturally in Egypt, but it occurs in Abyssinia[4, 5, 6]; in the Sudan; in Arabia in the Aden Protectorate; in the Hadramaut and elsewhere; in Armenia; in Asia Minor and in various Mediterranean islands.

Obsidian was used in ancient Egypt in small amount from predynastic times, at first in the form of flakes for use as implements, and as weapons, such as lance-heads, and later as amulets, beads, scarabs, eyes and pupils of eyes in statues and statuettes, small vases and other purposes, notable examples of its use being the head of

[1] No. J. 43507 A. [2] XXXVI: 11. [3] See p. 471.
[4] H. Salt, *A Voyage into Abyssinia*, pp. 190–4.
[5] W. H. Schoff, *The Periplus of the Erythraean Sea*, pp. 23, 66.
[6] Pliny, XXXVI: 67.

Amenemhet III (Twelfth Dynasty)[1] and a broken mask, foot and small piece and small head (Eighteenth Dynasty), the latter four from Karnak. Pliny states that 'Tiberius Caesar returned to the people of Heliopolis an obsidian image of Menelaus that had been found among the property left by one of the prefects of Egypt.[2]

The subject of the use of obsidian in ancient Egypt, with particular reference to its place of origin, has been discussed at length by Wainwright[3] and shortly by Frankfort,[4] the latter of whom gives some physical constants of obsidian from various sources, and Wainwright concludes that the obsidian used in Egypt was obtained from Armenia. In the last edition of this book I suggested that as there was a coasting trade down the Red Sea from very early times, and as obsidian occurred on the coast of Abyssinia, some at least of that employed in Egypt and the Sudan, especially that from the Sudan and from Nubia, may have been obtained from Abyssinia. Since then I have examined most of the obsidian objects in the Cairo Museum and many belonging to friends, and a large number of specimens from Abyssinia, Armenia, and the Mediterranean Islands, the results of which have been published,[5, 6] my conclusion being that 'There is ample evidence, therefore, that some of the material of the obsidian objects found in Egypt, and probably the greater part, was obtained from Abyssinia.'

Porphyritic Rock

The name porphyry (derived from a word meaning purple) was originally applied to a certain kind of purple-tinted rock (imperial porphyry) but in geology this primary significance has given place to one in which structure, and not colour, is the guiding characteristic, a porphyritic rock being any kind of igneous rock in which there are conspicuous crystals scattered throughout a differently coloured ground-mass or matrix of apparently homogeneous material.

Porphyritic rocks varying considerably both in the nature and size of the conspicuous crystals and also in colour are widely distributed in Egypt and occur near Aswan, in the eastern desert and in Sinai.

Porphyritic rock was used largely in the predynastic and early dynastic periods for making vessels, the particular variety generally

[1] C. Ricketts, *Journal of Egyptian Archaeology*, IV (1917), pp. 71–3.
[2] Pliny, XXXVI: 67.
[3] G. A. Wainwright, Obsidian, *Ancient Egypt*, 1927, pp. 77–93.
[4] H. Frankfort, *Studies in Early Pottery of the Near East*, II, pp. 190–3.
[5] A. Lucas, Obsidian, *Annales du Service*, XLI (1942), pp. 272–4.
[6] A. Lucas, Obsidian, *Annales du Service*, 1945 (in the Press).

chosen being black and white (white crystals in a black matrix). This stone occurs in the Esh-Mellaha range near the Red Sea (south of Jemsa Bay).[1]

The best known of the porphyritic rocks quarried anciently is without doubt the beautiful fine-grained purple-coloured rock (*porfido rosso antico*), often termed imperial porphyry, that was obtained from Egypt by the Romans from the first to the fourth century A.D. and employed extensively in Italy as an ornamental stone. This is found in three localities in the eastern desert, namely at Gebel Dokhan,[2, 3, 4] which is situated in about the same latitude as Asiut, but nearer the Red Sea than the Nile; at Gebel Esh,[2] some distance north-east of Dokhan and nearer the coast and at El Urf near Wadi Dib.[2] It was from the first-named locality, however, that the Romans obtained their supply.

Probably the Egyptian stone referred to by Pliny,[5] which he describes as being of a red colour and which he calls *porphyrites*, was imperial porphyry. The quarries, Pliny says, were able to furnish blocks of any dimensions however large. He also states that certain columns in the Egyptian Labyrinth were of *porphyrites*[6]; he further says that the steward in Egypt for the emperor Claudius brought to Rome from Egypt statues made of this stone, 'a novelty which was not very highly approved of, as no one has since followed his example.'[5]

Only four examples of the use of imperial porphyry in Egypt before Roman times are known to me, one being a small amuletic claw of 'prehistoric' date,[7] another part of a small fluted bowl, probably of protodynastic date,[8] found at Ballas in Upper Egypt,[9] the third, part of the lid of a small vase from the Third Dynasty step pyramid at Saqqara,[10] and the fourth, a fluted bowl 'like some pieces found at Naqada, which were probably of the same age.'[11] This was from 'B'

[1] Information kindly supplied by Mr. J. Dudler.

[2] T. Barron and W. F. Hume, *Topog. and Geol. of the Eastern Desert of Egypt*, pp. 118, 238, 241, 262.

[3] W. F. Hume, *Geology of Egypt*, II (Part 1), pp. 273–82.

[4] G. Andrew, On the Imperial Porphyry, *Bull. de l'Inst. d'Égypte*, XX (1937–1938), pp. 63–81.

[5] XXXVI: 11. [6] XXXVI: 19.

[7] W. M. F. Petrie, *Amulets*, p. 13; Pl. II (24*a*).

[8] Called Old Kingdom by Petrie, but Mr. Guy Brunton tells me that it is probably protodynastic.

[9] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, pp. 10, 36. Figured in *The Funeral Furniture of Egypt* (W. M. F. Petrie), Pl. XVI (209).

[10] Cairo Museum, No. J. 69493.

[11] W. M. F. Petrie, *The Royal Tombs*, II, p. 43, Pl. XLVIII (88).

cemetery at Abydos, S.D. 79. This, however, does not mean that imperial porphyry was being quarried at such early periods, as a piece sufficiently large to make the objects in question might well have been found lying loose on the surface of the desert near where the porphyry occurs.

Even at a late period date, imperial porphyry seems rarely to have been employed in Egypt, as only very few objects made from it can be traced, namely, a bust of a Roman emperor in the Cairo Museum; a carved lid of a sarcophague of late date in the Alexandria Museum[1]; a large mutilated statue of a male figure seated on a throne, possibly dating from the fourth century A.D., also in the Alexandria Museum[2]; a torso of a Byzantine emperor from Alexandria in the Emperor Frederick Museum at Berlin; some re-used pieces of Roman date built into the *Madrassa* of the Sultan Barquq mosque at Cairo,[3] and a thin polished slab (probably from a building) in the Museum of Arab art.[4]

Small pieces of broken worked objects of porphyritic rock, very dark green, or almost black in colour (black matrix with well-defined crystals of felspar of a light green colour) have been found on several occasions in Egypt, for example, there are four specimens in the Geological Museum, Cairo, presented by Père Bovier-Lapierre, which are labelled ' Labradorite-porphyry from Babylon and Fostat '; and in the Museum of Antiquities, Cairo, there are six small specimens, one (No. 65537) described in the register as ' End of 3rd. cent. A.D. From Kom Auchim, University of Michigan (Petersen) 1930–35 '; another (No. 66317) described as ' Roman, Mond-Myers Exped. Armant, 1936 '; a third marked ' Minia Mag.' (meaning from the store of the Inspector of Antiquities at Minia), and three not marked.

Mr. O. H. Little, Director of the Geological Survey, Egypt, tells me that he does not know of any occurrence of this rock in Egypt.

Professor Alan Wace informs me that quarries of this stone occur at the ancient Croceae in Greece, midway between Sparta and Gytheion, near the modern Levetsova, and were worked in Mycenean times and also in later Roman times and that vessels of this stone have been found at Mycenae and other Mycenean sites, and he showed me a small piece of such a vessel, which I compared with the specimens above in the Cairo Museums, and there is no doubt that the stone is

[1] Ev. Breccia, *Alexandrea ad Aegyptum*, 1922, p. 103. [2] *Id.*, p. 235.
[3] Kindly communicated by Professor K. A. C. Creswell.
[4] See R. Delbrueck, *Antike Porphyrwerke*, 1932.

identical, and, therefore, it is practically certain that the Egyptian objects, or the stone for them, were imported from Greece. This stone should not be confused with green breccia.

Quartzite

Quartzite and its occurrence in Egypt have already been dealt with in connexion with building materials,[1] but in addition to its use for building this stone was employed extensively for other purposes, principally for sarcophagi and statues, examples of the former being the sarcophagus in the Hawara pyramid (Twelfth Dynasty) and the sarcophagi of Tuthmosis I, Hatshepsut and Tut-ankhamun respectively (all Eighteenth Dynasty) and examples of the latter being a head of Dedefre (Fourth Dynasty) and the statues of Sesostris III (Twelfth Dynasty), Tuthmosis IV, and Senmut (both Eighteenth Dynasty), Ptah (Nineteenth Dynasty) and the emperor Caracalla (Roman).

With respect to the nature of the stone of which the Colossi of Memnon are made, which sometimes has been called quartzite and sometimes Nubian sandstone, Varille states[2] that '*Malgré l'avis des géologues aucun doute ne peut donc subsister sur la localisation de "la Montagne de grès" où furent taillés les colosses de Memnon*,' which he believes to be Gebel Ahmar near Cairo. The 'pebbly' nature of part of the stone, which seems to be a difficulty with some archaeologists in assigning the stone to Gebel Ahmar, may be closely matched in the very coarse material from that quarry.

Sandstone

Sandstone has already been dealt with as a building material,[3] but it was also employed for many other purposes, such as statues, stelæ and other objects. Notable examples of its use are the statues of Akhenaten (Eighteenth Dynasty) from Karnak, discovered a few years ago, and the colossal statues at Abu Simbel (Nineteenth Dynasty).

'Schist' (Greywacke), Tuff, Mudstone, Slate

After limestone, sandstone and granite, one of the most largely used rocks in ancient Egypt was what is generally called 'schist,' though, since it is a sedimentary and not a metamorphic rock, it cannot be

[1] See p. 79.

[2] A. Varille, *L'inscription dorsale du colosse méridional de Memnon*, in *Annales du Service*, XXXIII (1933), pp. 85–94.

[3] See p. 70.

schist. It is greywacke,[1] a fine-grained, compact, hard, crystalline, quartzose rock, very like slate in appearance and generally of various shades of grey, ranging from light to dark, with sometimes a greenish tint. With this may be grouped other allied rocks, namely, tuff (volcanic ash), mudstone and slate, since they are frequently so much alike that they cannot be distinguished except by a microscopical examination of thin sections, and they all occur in the same locality.

Greywacke and sometimes tuff and mudstone were employed during the predynastic and early dynastic periods for bracelets, bowls and vases and greywacke later for sarcophagi, naoi and statues, slate being possibly sometimes used for palettes.

Greywacke,[2, 3, 4] tuff[5, 6] and slate[7, 8] all occur in several localities in the eastern desert, though the principal and possibly the only ancient source of the two former was the neighbourhood of the Wadi Hammamat on the main road from Qena to Quseir, where there are extensive ancient quarries with more than 250 inscriptions ranging in date from the First Dynasty to the Thirtieth Dynasty.[9-12] These quarries and the stone from them are frequently mentioned in the ancient records.[13]

Until quite recently it was generally believed that the greywacke

[1] E. Fraas, *Zeitschr. der deutsch. geol. Gesellsch.*, Berlin, Bd. 52, Heft 4, 1900: W. F. Hume, *Geology of Egypt*, II, Part I, pp. 263–6: G. Andrew, The Greywackes of the Eastern Desert of Egypt, *Bull. de l'Institut d' Égypte*, 21 (1938–39), pp. 152–90: A. Lucas and Alan Rowe, The Ancient Egyptian *Bekhen*-stone, *Annales du Service*, XXXVIII (1938), pp. 127–56: G. Brunton, *Bekhen*-stone, *Annales du Service*, XL (1941), pp. 617–8: N. Shiah, Some Remarks on the *Bekhen*-stone, *Annales du Service*, XLI (1942), pp. 189–205.

[2] T. Barron and W. F. Hume, *op. cit.*, pp. 217–21, 224, 226, 236, 238–9, 249, 264.

[3] J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, pp. 337–50.

[4] W. F. Hume, *Geology of Egypt*, II (Part I), pp. 263–6.

[5] T. Barron and W. F. Hume, *op. cit.*, pp. 221, 236, 239, 249.

[6] W. F. Hume, *op. cit.*, pp. 249–50.

[7] T. Barron and W. F. Hume, *op. cit.*, pp. 217–8, 221, 226, 238, 264.

[8] W. F. Hume, *op. cit.*, pp. 194, 203, 227–8, 230, 256.

[9] A. E. P. Weigall, *Travels in the Upper Egyptian Deserts*, p. 39.

[10] J. Couyat et P. Montet, *Les inscriptions hiéroglyphiques et hiératiques du Ouadi Hammamât*, in *Mém. de l'Inst. franc. d'archéol. orientale du Caire*, XXXIV (1912), pp. 122–3.

[11] J. H. Breasted, *op. cit.*, I, 7, 10, 295–301, 386–9, 427–56, 466–8, 674–5, 707–9; IV, 457–68.

[12] W. M. F. Petrie, *A History of Egypt*, I (1923), pp. 102, 110, 144, 146, 153, 161, 175, 184, 193, 233; II (1924), pp. 97, 206; III (1928), pp. 119, 166, 280–1, 288, 294, 335, 340, 348, 360, 364, 369–70.

[13] J. H. Breasted, *op. cit.*, V (Index), p. 79.

of the Wadi Hammamat was the ancient *bekhen* stone, and this was thought to be proved by the fact that a certain naos of Nectanebo I, which is stated on the object itself to be of *bekhen* stone,[1] is certainly made of this rock. It has now been shown, however, that at least one other (and possibly more) totally different kind of stone was also termed *bekhen* stone, for example, the naos of Amasis II, which is not schist, but a fine-grained grey granite (psammite gneiss).[2] Although this stone contains a fair proportion of red felspar, the general appearance is grey and from a distance it is not unlike greywacke.

In the British Museum there are two small obelisks of Nectanebo II that bear inscriptions describing the stone of which they are made as *bekhen*. In the Museum Guide this stone is called 'black basalt'[3] and Breasted, on the authority of Gardiner, states that they are 'of the black basaltic rock of Hammamat.'[4] These obelisks have been much repaired, and afterwards apparently covered with a wash of black colour and it is impossible to ascertain the nature of the stone by simple inspection. Kuentz, however, has recently proved that a fragment in the Cairo Museum belongs to one of these obelisks,[5] and a specimen of this was taken by me and examined microscopically by Andrew,[6] who said it was the Wadi Hammamat greywacke.

Serpentine, Steatite

Serpentine and steatite are very similar in composition, though not identical, both being hydrated silicates of magnesium, but in different states of hydration.

Serpentine is a non-crystalline rock of a dull serpent-like mottled appearance, usually dark green to almost black in colour; it is fairly soft, though harder than steatite, and may readily be cut or scratched; it is widely distributed in the eastern desert, the principal centres being

[1] G. Roeder, *Naos*, pp. 55–6 (No. 70019). Roeder calls the stone '*grüner Schiefer*.' Earlier writers have variously termed it green breccia, green basalt and black granite, but it is undoubtedly the Wadi Hammamat greywacke.

[2] A. Varille, *Quelques données nouvelles sur la pierre bekhen des anciens Égyptiens*, in *Bull. de l'Inst. franc. d'archéol. orientale*, XXXIV (1933), pp. 93–102. G. Roeder, *op. cit.*, pp. 38–42 (No. 70011). This stone, which is in the Cairo Museum, is certainly '*grau gesprenkelter feinkörniger Granit*' as stated by Roeder.

[3] British Museum, *A General Introductory Guide to the Egyptian Collections*, 1930, p. 395.

[4] J. H. Breasted, *op. cit.*, I, p. 302, note *a*.

[5] C. Kuentz, *Obélisques*, pp. 61–2.

[6] Mr. G. Andrew, Sudan Government geologist.

the Baramia-Dungash area,[1] in Wadi Shait,[1] near Gebel Derrera, [1] in the hills north of Sikait[1] and at Gebel Sikait,[1] in the Muqsim area[1] and in the far eastern desert where it covers an area of about 400 square miles from Ras Benas southwards to Cape Elba.[2, 3] A green variety occurs in Wadi Umm Disi[4] (which is situated between Wadi Qena and the Red Sea) and at the foot of Gebel el Rebshi,[4] and a black variety in Wadi Sodmen,[4] both these latter places being north-west of Quseir. Serpentine was employed for vases and other objects[5] as early as predynastic times. A head of Amenemhet III (Twelfth Dynasty) is of this material.[6]

Steatite is a form of talc and is usually white or grey in colour, though occasionally it is smoke-black, this latter colour being natural and not artificial, as has been stated; it has a greasy or soapy feel and was used from Badarian times onwards for beads, vases and other small objects, which sometimes were glazed, the greater proportion of the scarabs known being of steatite, many glazed, but a large proportion not now glazed, though probably glazed originally, the glaze having perished.

Steatite is found at Gebel Amr near Aswan,[7] at Gebel Fatira[8] (about the latitude of Tahta, but much nearer the coast than the Nile) and in Wadi Gulan (opposite Gulan Island, which is north of Ras Benas), where it is now being exploited.[9] In the former locality there are ancient mines, which were reopened temporarily in 1918 when 137 tons of material were extracted [8]; it has been worked on a very small scale for many years by the local 'Arabs,' who fashion it into bowls and pipes.[10]

Stone Vessels

The earliest stone vessels made in Egypt that have been found are a few basalt vases of neolithic date from the Fayum and Merimde-Benisalâme respectively; then in chronological order come a few more

[1] W. F. Hume, (*a*) *A Prelim. Report on the Geol. of the Eastern Desert*, p. 34: (*b*) *Geology of Egypt*, Vol. II, Part I, pp. 111, 204.
[2] J. Ball, *The Geog. and Geol. of South-Eastern Egypt*, pp. 320–30.
[3] W. F. Hume, *Geology of Egypt*, II (Part I), pp. 144–59.
[4] T. Barron and W. F. Hume, *op. cit.*, p. 265.
[5] W. M. F. Petrie, *Prehistoric Egypt*, p. 44.
[6] C. Ricketts, *Journal of Egyptian Archaeology*, IV (1917), pp. 211–2.
[7] W. F. Hume, *Geology of Egypt*, II (Part I), pp. 131–2, 164–5.
[8] Mines and Quarries Department, *op. cit.*, p. 37.
[9] Information kindly supplied by Mr. O. H. Little, Director, Geological Survey of Egypt.
[10] P. S. Girard, *Description de l'Égypte: état moderne*, II, 1812, pp. 590–1.

basalt vases from the Badarian civilization, followed by a large number of vessels of different kinds of stone from various predynastic sites, the stones that can be identified from the archaeological reports being alabaster, basalt, breccia, granite, limestone, marble and porphyritic rock from the early predynastic period, and the same stones, with the exception of granite, but with the addition of diorite (speckled, not the Chephren-statue kind), greywacke (schist), gypsum, mudstone, serpentine, steatite and volcanic ash from the middle and late predynastic periods. About 73.5 per cent of the stone used was of three kinds only, namely, in order of the numerical frequency of their occurrence, limestone, 36.0 per cent; basalt, 21.5 per cent; alabaster, 16.0 per cent and about 17.5 per cent breccia, marble and serpentine together, leaving only about 9.0 per cent for the other kinds of stones mentioned.

The stone vessel industry reached its zenith during the early dynastic period, and nowhere has there been found such a wealth of beautifully-made, handsome stone vessels as in Egypt, the stones employed being of the kinds already mentioned, together with the Chephren-statue variety of diorite, flint, red jasper, obsidian, amethystine quartz, opaque quartz and rock crystal, all these stones, except obsidian, which was imported, occurring naturally in Egypt. Petrie states[1] that ' From the point of view of magnificence and skill in using hard and beautiful stones we must say that the Egyptians gradually rose to their highest level in the later prehistoric and early dynastic times,' and, since this was written many thousands of additional vessels of early dynastic date have been found at Saqqara.

With reference to the royal tombs of the early dynastic period Petrie says[1] that ' hundreds of stone bowls were buried with each king of the Ist. Dynasty, and many are found in tombs of the IIIrd. and IVth. Dynasties ' and again,[2] ' Roughly speaking, between 10,000 and 20,000 pieces of vases of the more valuable stones were found, and a much larger quantity of slate and alabaster.' In the First Dynasty tomb of Aha found by Emery at Saqqara there were 653 stone vessels of which 93.3 per cent were alabaster and 3.8 per cent basalt, but no greywacke (schist), the other stones used being breccia (two); limestone (fourteen); porphyritic rock (two); and serpentine (two).[3] In the First Dynasty tomb of Hemaka at Saqqara (later than that of Aha) there were 384 stone vessels, of which 50.0 per cent were alabaster; 34.4 per cent

[1] W. M. F. Petrie, *Diospolis Parva*, p. 18.
[2] W. M. F. Petrie, *The Royal Tombs*, I, p. 18. [3] W. B. Emery, *Hor-Aha*.

greywacke (schist), with a few of mudstone and volcanic ash, and the rest (11.7 per cent) of eight other different kinds of stones, but no basalt.[1] In the Third Dynasty step pyramid at Saqqara there were literally tens of thousands of stone vessels, more than 400 having been found in a shaft in the south wall, and about 30,000 in one of the galleries, the weight of these latter being estimated at about ninety tons.[2]

Towards the end of the Old Kingdom the number of stone vessels decreased considerably, most of the harder stones going entirely out of use for this purpose, thus in the Fourth Dynasty tomb of Queen Hetepheres there were only thirty-eight stone vessels, all of which were of alabaster.[3] This, however, was a reburial and not the original tomb, which had been robbed, but whether any stone vessels had been taken by the robbers, which seems unlikely, or left behind in the original tomb, when the transfer to the new tomb was made, it is, of course, impossible to determine.

From the Middle Kingdom a few vases of alabaster, a very small one of lapis lazuli, another of carnelian and a few of obsidian have been found, and a fresh, though not very hard, stone came into use, chiefly for small toilet vases, this being what until recently was called 'blue marble,' but which is now known to be anhydrite, almost certainly an Egyptian stone, though where it is found is not known.[4] Petrie says[5] 'But in the XIIth. Dynasty the softer serpentine and alabaster supplanted the fine diorites and porphyries and in the XVIIIth. Dynasty the art of working hard stone was forgotten for anything but statuary.'

In the Eighteenth Dynasty tomb of Tut-ankhamun there were altogether seventy-nine stone vessels, all but three being alabaster, these three exceptions being serpentine, a fairly soft and easily worked stone.

With respect to the method of making these stone vessels, the following descriptions may be quoted:

Quibell states[6] that 'The outside of the vase was finished before the hollowing out of the block was commenced. On the shoulder of two vases we have noticed two horizontal grooves, opposite to one another, which as Mr. Lacau observed, were probably intended to give a good hold to the tool by which the block was rotated. An amethyst vase

[1] W. B. Emery, *The Tomb of Hemaka*, pp. 55–6.
[2] C. M. Firth and J. E. Quibell, *The Step Pyramid*, p. 130.
[3] Now in the Cairo Museum.
[4] See p. 471.
[5] W. M. F. Petrie, *Diospolis Parva*, p. 18.
[6] J. E. Quibell, *Annales du Service*, xxxv (1935), pp. 77–8.

spoilt in the making . . . was finished externally, but the inside, only begun, showed a rough surface obtained by careful picking with a point grain by grain. It seems that for dressing the outer surface the vase itself was rotated, for hollowing the inside the vase was fixed, embedded in pitch[1] or clay.' With reference to the use of tubular drills Quibell says[2] ' nothing is more certain than that such drills were in current use ' and ' Cylindrical drills were used and used in vase-making; we have found cores of diorite and granite, also the ends of drill holes in alabaster and dolomite (?). But by what device the first cylindrical hole in a narrow necked vase was enlarged into the shoulder is still far from clear.' Quibell and Green[3] many years earlier found at Hierakonpolis and published illustrations of (*a*) a diorite vase-grinder; (*b*) a diorite vase-grinder in position on a block of rock crystal roughly chipped to shape ready for grinding and boring; (*c*) three limestone vase-grinders; (*d*) three sandstone vase-grinders; and (*e*) a vase maker's workshop with bench and two vase-grinders.

Petrie says[4] of the predynastic stone vases ' All these stone vases were shaped by hand without any lathe or turning instrument, the lines of scraping and polishing running diagonally; the insides were ground out by blocks of sandstone, or emery.' [5]

Petrie also says[6] of the stone vessels from the Fourth Dynasty ' Not only was a rotating tool employed, but the further idea of rotating the work and fixing the tool was also familiar to the earliest Egyptians. The fragments of bowls turned in diorite, which are here, will show this. One piece of the bottom of a bowl shows the characteristic mark of turning . . . Other specimens of turning in black granite, basalt and alabaster, all of the pyramid period, are also here. The finest examples of turning in hard stone are in the British Museum.' Also[6] ' A very favourite plan for narrow-necked vessels was to turn them in two or three parts, and join them together, sometimes finishing off the inside on a fresh centering on the lathe. For this finishing and also for the hollowing out vessels in one piece a hook tool must have been used.'

Petrie further says[7] ' The interior of stone vases was cleared by a tube-drill hole of the size of the mouth, and then enlarging the inside

[1] Certainly not pitch.
[2] J. E. Quibell, *Annales du Service*, xxxv (1935), pp. 77–8.
[3] J. E. Quibell and F. W. Green, *Hierakonpolis*, II, p. 17; Pls. LXII, LXVIII.
[4] W. M. F. Petrie, *Diospolis Parva*, p. 19.
[5] Not emery, see pp. 90–2.
[6] W. M. F. Petrie, *Journ. Anthrop. Inst.*, XIII (1883).
[7] W. M. F. Petrie, *Social Life in Ancient Egypt*, pp. 153–4.

by drills of stone, fed with emery,[1] skew across the hole . . . The outside was worked diagonally by blocks of emery.[1] There was no lathe cutting, even in Roman times; . . . All kinds of short cuts were made in decadent times, as forming stone vases in two halves joined round the greatest diameter (in IInd. dynasty); drilling a vase right through and plugging the bottom; making a lip in a separate piece; and using a paste of blackened mud, with chips of white limestone in it to imitate porphyry.' Again,[2] 'Tube drills were also in constant use for beginning the hollowing out of the great diorite bowls . . .' and 'The tube drills were also used in hollowing more upright vessels.'

Reisner refers[3] to 'boring stone vessels with a boring stone fixed in a forked shaft weighted at the top and turned by a crank,' which he calls[4] 'perhaps the first machine ever invented by man,' and he also states[3] that 'In addition to the stone borer, a cylindrical tube borer was also used, especially for limestone and alabaster.'

The use of a weighted crank drill for hollowing out stone vases is pictured in a number of tombs, for example on a limestone relief from a tomb of Fifth Dynasty date from Saqqara, which is now in the Cairo Museum[5]; in a Fifth Dynasty tomb at Saqqara[6]; in the Sixth Dynasty tomb of Mereruka at Saqqara[7]; in a Sixth Dynasty tomb at Deir el Gebrawi[8]; in a Twelfth Dynasty tomb at Meir[9]; in three Eighteenth Dynasty tombs[10] and in a Twenty-sixth Dynasty tomb in the Theban necropolis.[11] Also a similar drill is shown in use in a wooden model of Middle Kingdom date (or earlier) from Saqqara, which is now in the Cairo Museum.[12]

In the thickness of the walls (not penetrating) of several alabaster vessels from the First Dynasty tomb at Hemaka at Saqqara there are

[1] Not emery, see pp. 90–2.
[2] W. M. F. Petrie, *Journ. Anthrop. Inst.*, XIII (1883).
[3] G. A. Reisner, *Mycerinus*, pp. 179–80.
[4] G. A. Reisner, *The Early Dynastic Cemeteries of Naga-ed-Dêr*, I, p. 134.
[5] No. J. 39866.
[6] G. Steindorff, *Das Grab des Ti*, p. 134, Pl. 134.
[7] (*a*) J. de Morgan, *Recherches sur les origines de l'Egypte*, I, p. 165; (*b*) P. Duell and Others, *The Mastaba of Mereruka*, I, Pls. 30, 31.
[8] N. de G. Davies, *The Rock Tombs of Deir el Gebrawi*, I, Pl. XIII.
[9] A. M. Blackman, *The Rock Tombs of Meir*, I, Pl. V.
[10] P. E. Newberry, The Life of Rekhmara, Pl. XVII. N. de G. Davies, (*a*) *The Tomb of Two Sculptors at Thebes*, Pl. XI; (*b*) *The Tomb of Puyemrê at Thebes*, Pls. XXIII, XXVII.
[11] N. de G. Davies, *The Rock Tombs of Deir el Gebrâwi*, I, Pls. XIII, XXIV.
[12] No. J. 45319. J. E. Quibell and A. G. K. Hayter, *Excavations at Saqqara, Teti Pyramid, North Side*, p. 40; Pl. 24.

holes made by a tubular drill. Also an oval shallow dish of dolomite has shallow tubular-drill holes that do not penetrate the vessel, but are similarly placed one near each end. In this connexion, though it is not a vessel, a hollow wand of alabaster of Fourth Dynasty date from Giza may be mentioned.[1] It is broken in several pieces so that the interior may be seen. One end is closed and one end is open and in the inside of the closed end is part of the narrow core, proving that the drilling was done by means of a tubular drill.

Certain statements in the literature of archaeology having reference to the origin of the stone-vase industry in Egypt may now be quoted, which are as follows:

'But as early as S.D. 38 a fresh influence came in . . . Its origin has been provisionally assigned to the Red Sea district as it introduced hard stone vases . . .'[2]

'The home of this second civilization must have been mountainous by the supply of stone instead of clay for vases . . .'[3]

'Petrie has rightly insisted that the home of the stone vase industry can ultimately only be sought in the mountains between Egypt and the Red Sea where all the stones used for the purpose do actually occur . . .'[4]

'The only definite indication as to their home is the fact that their most characteristic contributions to the prehistoric civilization are the stone vases and their pottery imitations: and the region which is most likely to have bred people knowing how to work stone and which is near enough to Egypt to allow permanent intercourse with the Nile Valley . . . is the Arabian desert along the western shore of the Red Sea.'[5]

Peake and Fleure say 'and stone bowls and vases seem first to have been made in the Arabian desert, which lies between the Nile and the Red Sea . . .'[6]; 'stone pots, which were introduced into the valley about this time . . .'[6] 'The inhabitants of the Arabian desert may have learned of themselves how to make stone bowls . . .'[6] 'At the same time appeared higher up the Nile, possibly from the Arabian desert on the east, a fresh people who were skilled in the art of making stone bowls'[6]; 'the stone bowl people who had perhaps come from the

[1] Now in the Cairo Museum, No. J. 60545.
[2] W. M. F. Petrie, Egypt and Mesopotamia, *Ancient Egypt*, 1917, p. 33.
[3] W. M. F. Petrie, *Prehistoric Egypt*, p. 48.
[4] A. Scharff, *Journal of Egyptian Archaeology*, XIV (1928), p. 273.
[5] H. Frankfort, *Studies in the Early Pottery of the Near East*, I, p. 100.
[6] H. Peake and H. J. Fleure, *Peasants and Potters*, pp. 71, 76, 80, 142.

Arabian desert . . .'[1] 'The use of stone bowls, first introduced from the Arabian desert at the beginning of the predynastic period . . .'[1]

Often no reasons are given for the statements made, but when reasons are advanced they are, first, that the stones used for the predynastic stone vessels occur in the eastern desert, and, second, that 'Even now the inhabitants . . . still use stone for the objects that are made of pottery in the Nile Valley, as for instance, vessels and pipes.'[2] At first thought these facts, which are not disputed, might appear to provide a reasonable foundation for the statements, but on reflection this will be found to be an illusion, as will now be shown.

It is possible to determine from the archaeological reports only the approximate and not the exact number of predynastic stone vessels made from each of the different kinds of stone used. These approximate figures were put together and published by me some time ago,[3] since when I have recalculated them in a different manner and find that the fresh results differ from the previous ones only by two-and-a-half per cent. Although it is in no way claimed that the results are anything more than a rough approximation, they are sufficiently accurate to establish the arguments based on them.[4] The figures are as follows:

Nature of Stone	*No. of Vessels*	*Fayum, Nile Valley, Aswan*	*E. Desert*
		%	%
Alabaster[5]	48	16.0	—
Basalt	65	21.5	—
Breccia	25	8.0	—
Diorite[6]	2	1.0	—
Granite	7	2.0	—
Gypsum	1	0.5	—
Limestone	108	36.0	—
Marble	17	—	5.5
Porphyritic rock ...	6	—	2.0
Schist[7]	4	—	1.5
Serpentine.	12	—	4.0
Steatite	7	—	2.0
	302	85.0	15.0

[1] H. Peake and H. J. Fleure, *Priests and Kings*, pp. 63, 88.
[2] H. Frankfort, *op. cit.*, pp. 100, 101.
[3] A. Lucas, Egyptian Predynastic Stone Vessels, *Journal of Egyptian Archaeology*, XVI (1930), pp. 200–12.
[4] Vessels published since the date of my article (1930) have not been included.
[5] Calcite.
[6] Not the Chephren-statue variety, but a speckled variety, probably from Aswan.
[7] Includes greywacke, mudstone and volcanic ash.

If these results are accepted as approximately correct, which I believe them to be, then a comparatively small proportion only (about 15 per cent) of the stones used for making the predynastic vessels were obtained from the far eastern desert, and by far the larger proportion (about 85 per cent) came from the Fayum, Aswan and the Nile Valley, which involves the further proposition that the home of the stone-vessel industry was not in the eastern desert, but in the Nile Valley (in which Aswan may reasonably be included). The Nile Valley, in the sense in which it is used here, comprises the low hills and plateaux bordering the valley, and the side valleys that enter the river valley to within a distance that could readily be worked by the valley people from their homes (which during the predynastic period must have been further from the river and nearer the cliffs than they are to-day on account of the marshes then bordering the river), in the same manner as rock salt, gypsum for plaster, limestone for building, and nitrous earth for the crops are now worked. Even the stones that occur at a considerable distance from the Nile were also available near the Koptos-Quseir road, along which there was constant traffic at an early period, as is proved, for instance, by the Red Sea shells which are such a marked feature of the earliest graves. The Nile Valley, therefore, and not the eastern desert, was the home of the early stone-vase industry.

The facts that the Beja tribe of Arabs in the eastern desert use stone at the present day for making cooking vessels and tobacco pipes,[1, 2] and that the Sinai Arabs also make stone pipes,[2] have no bearing whatever on the problem, since the stone employed by these people is steatite, which is so soft that it may be cut readily with a knife, and since the vessels made are very crude. There is no evidence at all for postulating a desert stone-vessel-making people, and also no need, since there is no proof of any break in the continuity of the stone-vessel industry, but only evolution and progress, the beginning being with basalt (one of the hardest stones used) during the neolithic period, and, as time passed, more kinds of stone were employed and more vessels made, until the culmination in numbers, material and workmanship was reached in the early dynastic period.

[1] P. S. Girard, *Description de l'Égypte, état moderne*, II, 1812, pp. 590–1.
[2] G. W. Murray, *Sons of Ishmael*, p. 84.

CHAPTER XVIII

WOOD

Egypt is, and during the historical period always has been, poorly provided naturally with large trees and it has been necessary from very early times to import a portion of the wood required (though probably not so much as is sometimes thought), a practice that continues to the present day, and on the Palermo Stone it is stated[1] that as early as the reign of Snefru (Third Dynasty) 40 ships laden with timber were brought to Egypt.

Foreign Timber

The places from which the foreign timber (excluding ebony) was obtained were Arrapachitis,[2] Assur,[3] God's Land,[4] the Hittite country,[5] Lebanon,[6] Naharin,[7] Punt,[8] Retenu[9] and Zahi,[10] all except Punt (the wood from which consisted of ebony and certain sweet and fragrant woods, the latter manifestly not being for use as timber but probably for making incense and perfumes) being situated in western Asia.

Although a large number of different kinds of imported wood are mentioned by name in the ancient records, only comparatively few of these names have been translated[11] and, even where this has been done, the translation is often only a tentative one and is not always generally accepted and the identity of much of the imported timber still remains doubtful.

The only certain method of identifying wood is by an expert examination of its structure with a microscope, and the following list gives all such identifications of foreign woods (except ebony) found in Egypt that can be traced:

[1] J. H. Breasted, *Ancient Records of Egypt*, I, 146. [2] II, 509, 512.
[3] II, 449. [4] II, 321, 888. [5] II, 485. [6] III, 94; IV, 577.
[7] II, 434. [8] II, 265; III, 527.
[9] II, 447, 471, 491, 509, 525, 838. [10] II, 490.
[11] In Breasted's translation of the ancient Egyptian records, in addition to such indefinite names as aromatic wood, fire wood, fragrant wood and sweet wood, the names of 12 woods, out of a total of 24, are left untranslated.

Wood	*Date*	*Object*
Ash	XVIIIth Dynasty	Compound bow[1] and felloes of chariot[2]
Beech	3rd to 4th century A.D.	Mummy label[3]
Box	XVIIIth Dynasty	Chair and razor handle[4]
Box	XVIIIth Dynasty	Inlay[5]
Box	3rd to 4th century A.D.	Mummy labels[3]
Cedar	Predynastic period	Small pieces[6]
Cedar	Xth to XIth Dynasty	Coffins[3]
Cedar	XIIth Dynasty	Sarcophagus[7, 8]
Cedar	Middle Kingdom	Coffin[9]
Cedar	XVIIIth Dynasty	Shrines (panels)[10]
Cedar	XVIIIth Dynasty	Dowels[10]
Cedar	XXth to XXVIth Dynasty	Coffin[9]
Cedar	XXVIth Dynasty	Coffin[7]
Cedar	Ptolemaic	Coffin or coffins (two pieces)[11]
Cedar	About 2nd century A.D.	Tree trunk (small)[12]
Cedar	Late	Small piece[13]
Cypress	Predynastic period	Small pieces[6]
Cypress	IIIrd Dynasty	Coffin[14]
Cypress	Middle Kingdom	Coffin lid[15]
Cypress	XVIIIth Dynasty	Small box[5]

[1] Identified for me by Dr. L. Chalk.

[2] Ridgeway (*The Origin and Influence of the Thoroughbred Horse*, 1905, pp. 498–9), quoted by G. Clark, *Antiquity* 15, 1941, p. 58.

[3] K. P. Oakley, *Woods used by the Ancient Egyptians*, in *Analyst*, LVII (1932), pp. 158–9.

[4] A. Lansing and W. C. Hayes, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1935–1936*, pp. 13, 28.

[5] W. C. Hayes, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1934–1935*, p. 29.

[6] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, pp. 62–3.

[7] R. Engelbach, *Ancient Egyptian Woods*, in *Annales du Service*, XXXI (1931), p. 144.

[8] The coffin and canopic box belonging to this burial are also cedar.

[9] Identified by Dr. L. Chalk (The Imperial Forestry Institute, University of Oxford, *Eighth Annual Report*, 1931–2, p. 11).

[10] Several specimens identified by Dr. L. Chalk, *op. cit.*, p. 11; a number of other specimens identified by me. Three further specimens were identified for me at the Royal Botanic Gardens, Kew.

[11] W. Ribstein, *Zur Kenntnis der im alten Ægypten verwendeten Hölzer*, in *Botanisches Archiv.*, pp. 194–209. Herausgegeben von Dr. Carl Mez, Königsberg. Neither volume nor date given.

[12] G. W. Murray, *A Small Temple in the Western Desert*, in *Journal of Egyptian Archæology*, XVII (1931), p. 82.

[13] Sir R. Mond and O. H. Myers, *The Bucheum*, I, p. 59.

[14] Identified by Dr. L. Chalk (The Imperial Forestry Institute, University of Oxford, *Ninth Annual Report*, 1932–3, p. 12).

[15] Found by Petrie at Lahun. Examined by Professor Irving Bailey, Harvard University. Communicated by G. Brunton.

Wood	*Date*	*Object*
Cypress	End of Saïte period	Coffin[1]
Elm	XVIIIth Dynasty	Chariot[2]
Fir	Vth Dynasty	Vase (part of)[3]
Fir	Late 7th century B.C.	Coffin[1]
Fir	Roman	Mummy label[4]
Hornbeam	XVIIIth Dynasty	Chariot yoke[5]
Juniper	IIIrd Dynasty	Coffin[2]
Juniper	About IIIrd Dynasty	Lid (small)[4]
Juniper	Roman	Mummy label[4]
Lime	3rd to 4th century A.D.	Mummy label[6]
Liquidambar	XVIIIth Dynasty	Piece (shaped)[7]
Oak	XVIIIth Dynasty	Dowel,[8] pole, axle and spokes of chariot[5]
Pine	Predynastic period	Piece (trimmed)[9]
Pine	IIIrd Dynasty	Coffin[2]
Yew	VIth to XIIth Dynasty	Coffins[10]
Yew	VIth to XIIth Dynasty	Coffin peg[10]
Yew	XVIIIth Dynasty	Head of Queen Tiy [11, 12]

The various woods enumerated may now be considered.

Ash

The ordinary ash (*Fraxinus excelsior*) is common in Europe, in Asia, including Asia Minor, and in North Africa. One species (*Fraxinus ornus*) grows on the Lebanon mountains in Syria. The wood is hard, tough and elastic. The only specimens of ash from ancient Egypt that are known to me are the wood of a compound bow from the tomb of Tut-ankhamun and that used for the felloes of the Eighteenth Dynasty Egyptian chariot in the Museum at Florence.[5]

[1] R. Engelbach, *Ancient Egyptian Woods*, in *Annales du Service*, XXXI (1931), p. 144.

[2] Identified by Dr. L. Chalk (The Imperial Forestry Institute, University of Oxford, *Ninth Annual Report*, 1932–3, p. 12).

[3] L. Borchardt, *Das Grabdenkmal des Königs Neſer-ir-ke-Re*, pp. 61, 63.

[4] W. Ribstein, *Zur Kenntnis der im alten Ægypten verwendeten Hölzer*, in *Botanisches Archiv.*, pp. 194–209. Herausgegeben von Dr. Carl Mez, Königsberg. Neither volume nor date given.

[5] Ridgeway (*The Origin and Influence of the Thoroughbred Horse*, 1905, pp. 498–9), quoted by G. Clark, *Antiquity* 15, 1941, p. 58.

[6] K. P. Oakley, *Woods used by the Ancient Egyptians*, in *Analyst*, LVII (1932), pp. 158–9.

[7] Identified at the Royal Botanic Gardens, Kew.

[8] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 39; III, p. 153.

[9] G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 62–3.

[10] G. Beauvisage, *Recherches sur quelques bois pharaoniques*, in *Recueil de travaux*, XVIII (1896), pp. 78–90.

[11] L. Borchardt, *Der Porträtkopf der Königin Teje*, p. 10.

[12] L. Wittmack, *Holz vom Porträtkopf der altägyptischen Königin Teje*, in *Berichte der Deutschen botanischen Gesellschaft*, XXX (1912), pp. 275–8.

Beech

The beech tree (*Fagus sylvatica*) is found both in Europe and in western Asia and the occurrence, therefore, of a small specimen of the wood in Egypt at a late date is not surprising.

Birch

This wood is not known with certainty from ancient Egypt, but only the bark,[1] though Mackay suggests that certain staves of Old Kingdom date from Kafr Ammar may be from a species of birch.[2]

Box

The box tree (*Buxus sempervirens*) grows in Europe, western Asia and north Africa and, since the wood was used by both the Greeks[3] and Romans,[4] it is in no way strange that a small piece should have been found in Egypt at a late period. But it has also been found much earlier. Thus, parts of a carved chair, a carved handle for a bronze razor and applied strips framing inlays of faience on a jewel box, all of Eighteenth Dynasty date, have been found at Thebes. The oriental box tree (*Buxus longifolia*) grows in Palestine and Syria. The kings of Mitanni and Alasia respectively sent box-wood objects and box-wood to Egypt.[5]

Cedar

There is only one family of true cedars, which comprises three members, namely, the cedar of Lebanon (*Cedrus Libani*), the Atlas cedar (*Cedrus atlantica*) and the Indian cedar (*Cedrus deodara*). Although it is not impossible that the wood of the Atlas cedar (which grows on the Atlas mountains in Morocco) might have found its way occasionally into Egypt, there is no evidence and little probability of this, the ancient imports of timber into Egypt (excepting ebony) being chiefly from Syria. Although, the woods of the Lebanon and Atlas cedars cannot be distinguished from one another microscopically, it may be accepted that any cedar wood found in Egypt is *Cedrus Libani* and, since its use goes back to the predynastic period, it was evidently

[1] See Bark, p. 514.
[2] E. Mackay, *Heliopolis, Kafr Ammar and Shurafa*, W. M. F. Petrie and Others, p. 10.
[3] Theophrastus, *Enquiry into Plants*, v: 3, 7; 7, 7–8.
[4] Pliny, xvi: 28.
[5] S. A. B. Mercer, *The Tell-el-Amarna Tablets*, 1, pp. 145, 147, 205.

being imported into Egypt at that early date. It is found also plentifully on the Taurus mountains in Asia Minor.[1]

At the present day a large number of different trees that are not cedar are called cedars,[2] among them being one (an American juniper, *Juniperus virginiana*) that yields the fragrant red wood employed for making pencils, cigar boxes and other objects. The modern 'oil of cedar,' too, is generally a product of this same tree. This confusion of nomenclature, however, is not new, as the classical writers, both Greek and Latin, applied the term 'cedar' to many trees that were not cedars, but often junipers.[3] It seems, therefore, not only possible, but probable, that the word 'cedar' has been used always in a loose manner and that, even when there is no longer any difference of opinion about the ancient Egyptian name for the true cedar, there will still remain a doubt whether a particular wood so designated was indeed cedar, though in view of the results given, there cannot be any uncertainty about the fact that the wood of the true cedar was employed in Egypt for making sarcophagi, coffins and other appurtenances of burial, such as shrines, from at least as early as the Tenth or Eleventh Dynasty to as late as the Ptolemaic period.

The Eighteenth Dynasty shrines of which specimens of the wood have been examined are those that enclosed the stone sarcophagus (containing the nest of three coffins with the mummy) of Tut-ankhamun.[4, 5] These shrines are large, oblong, roofed wooden structures with a double door at one end and are covered, both inside and outside, with a thin coating of plaster (made of whiting and glue), which is decorated with funerary scenes and inscriptions and then thickly gilt, exceptions being the roofs of the two larger shrines, which are mostly coated with black varnish, and the outside of the largest shrine, which in addition to gold, is ornamented with blue faience. In the tomb, the shrines were placed one outside the other, the outermost, which practically filled the burial chamber, being about 16½ feet (5 metres) long, 11 feet (3.3 metres) wide and 9 feet (2.8 metres) high. Each shrine consists of a number of sections, which

[1] H. B. Tristram, *The Natural History of the Bible*, 1911, p. 344.

[2] H. Stone, *The Timbers of Commerce*, p. 297.

[3] A. Lucas, *'Cedar'-tree Products employed in Mummification*, in *Journal of Egyptian Archaeology*, XVII (1931), p. 14.

[4] Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I, pp. 180–3; Pl. XLV.

[5] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, pp. 31–3, 39–47; Pls. XII, XIII, XIV, XV, LIV, LVI, LVII, LVIII, LIX.

had been assembled in the tomb, and which had to be taken apart to remove them from the tomb, the larger sections or panels being made of separate planks fastened together with wooden pegs, the sections being joined by means of mortise and tenon joints or flat dowels.[1] The wood is about 2¼ inches (57 mm.) thick. It was not possible to see any part of the bare wood until the shrines had been taken to pieces and then only some of the edges and parts of the tenons and dowels and, before any critical examination could be made, it became necessary to treat both surfaces of all the sections with melted paraffin wax in order to consolidate and preserve the gilt plaster, in doing which the wood of the edges of the sections and of the exposed parts of the tenons and dowels also became covered with wax, thus concealing its appearance. However, when the surplus wax was being removed (which was done by me at the Cairo Museum by means of electrical heaters) a certain amount of examination was found possible and was made. This consisted of (*a*) a careful examination of all the exposed parts with the naked eye and with a lens[2] and the comparison of the wood with small specimens previously taken from the shrines, sections of which had been examined microscopically by Dr. L. Chalk of the Imperial Forestry Institute, Oxford, and identified as cedar and sidder respectively, and (*b*) a microscopical examination of additional sections (prepared for me in Germany), using Dr. Chalk's photomicrographs as standards, the sections having been taken from broken edges of the planks and from a large number of the dowels (many of these having been sawn off, either in the tomb to enable the sections to be taken apart, or to facilitate packing, or in the Museum to allow the sections to be fitted together when the shrines were being re-erected.)[3]

The main wood of the shrines, so far as it has been examined, is cedar, but as much of it cannot be seen and never has been seen since the shrines were made more than 3,200 years ago, the nature of the

[1] In most cases the dowels were wood, but in some instances they were of copper (analysed by me and found to be free from tin and therefore not bronze). In many cases, too, the dowels, although of wood, were not of the same kind of wood as the planks. Altogether 177 dowels were examined by me, of which 107 (60 per cent) were probably cedar and 70 (40 per cent) were probably sidder (*nabk*). In the largest (outermost) shrine, out of 93 tongues examined, 47 were probably cedar and 46 probably sidder (*nabk*).

[2] After scraping off the wax.

[3] In the case of the largest shrine, there were so many dowels broken and missing that these had to be replaced before the shrine could be erected, which was done with new dowels of beech wood.

part concealed naturally cannot be proved, though, judging both by analogy and probability, this, too, is cedar.

The wooden dowels, so far as they have been examined, are essentially of two very distinct kinds, which differ considerably in appearance and thickness, one being light-brown with characteristic darker reddish-brown markings, which varies in thickness from about 0.67 inch (17 mm.) to about 0.79 inch (20 mm.), and the other being of a uniform and different shade of brown without conspicuous markings and much thinner, being only from about 0.24 inch (6 mm.) to about 0.43 inch (11 mm.). The former is cedar and the latter is sidder (*nabḳ*). One dowel, however, was oak and one acacia, and the matter will be discussed further in connexion with these woods.[1]

Cypress

Although a few specimens of the cypress tree (*Cupressus sempervirens*) are grown in gardens in the Delta at the present day, the cypress is not an Egyptian tree and probably was not introduced into the country until modern times; it grows, however, plentifully in both southern Europe and western Asia. Since the wood of predynastic date identified as probably cypress was found at the same place as some cedar, which is a typically Syrian tree, that particular piece of cypress had probably been imported from Syria and, therefore, possibly also the later specimens. The Third Dynasty specimen was from a 6-ply wooden coffin found in the step pyramid at Saqqara.[2, 3] The Eighteenth Dynasty specimen was a small jewel box having a lid of tamarisk and inlays of box wood and faience.

Ebony

Whatever difficulties there may be in the recognition of most of the kinds of wood imported into Egypt, there are none with respect to ebony, the ancient Egyptian name (*hebeny*) being well known and the wood, on account of its characteristic colour and appearance, being recognized readily without microscopical examination.[4] The ancient

[1] The use of coniferous wood and other coniferous tree products in ancient Egypt is discussed and a very large number of references are given by V. and G. Täckholm and M. Drar in *Flora of Egypt*, I, Cairo, 1940, pp. 46–50, 64–79.

[2] J. P. Lauer, *Fouilles du Service des Antiquités à Saqqarah*, in *Annales du Service*, XXXIII (1933), pp. 163–5; Fig. 5; Pl. II.

[3] A. Lucas, The Wood of the Third Dynasty plywood Coffin from Saqqara, *Annales du Service*, XXXVI (1936), pp. 1–4.

[4] General reference. V. Loret, L'ébène chez les anciens égyptiens, *Receuil de travaux*, VI (1885), pp. 125–30.

Egyptian (Sudan) ebony is not always black, but may be partly or wholly dark brown.

In the ancient Egyptian records ebony is stated to have been obtained from Genebteyew,[1] Kush,[2] Negro Lands,[3] Nubia,[4] Punt[5] and the South Countries,[6] all of which are situated to the south of Egypt. This does not mean that ebony grew in all these places, but merely that it reached Egypt from the south. Even at the beginning of last century, small logs of ebony, about a foot in length, were articles of trade at Shendi,[7] which is situated a little north of Khartum. In the Punt scenes in the mortuary temple of Hatshepsut at Deir el Bahari, Egyptians are shown cutting branches from ebony trees.[8]

Herodotus states[9] that ebony was an article of tribute from Ethiopia; Diodorus[10] and Strabo[11] both say that ebony trees grew in Ethiopia; but Pliny, commenting upon the statement of Herodotus, throws doubt upon its accuracy[12] and in a later book states[13] that the ebony tree did not grow in Egypt, in which term apparently he included Ethiopia. Dioscorides says[14] that Ethiopian ebony is the best.

What is ordinarily called ebony is the black heart wood of a number of different kinds of tropical trees, up to about forty years ago the true ebony of commerce being the wood of *Diospyros ebenum*, which grows in southern India and Ceylon, but at the present time it is largely *Diospyros Dendo* from West Africa. As, however, the word ebony is derived from the ancient Egyptian *hebeny*, the original ebony was that known in ancient Egypt, which has been identified as the wood of *Dalbergia melanoxylon*,[15] a tree that grows in tropical Africa. A specimen of ebony of Fifth Dynasty date examined by Wittmack is stated to be *Diospyros ebenum*.[16] But as it seems most improbable that ebony should have been obtained from India or Ceylon at such an early period, and as it is difficult to be sure of the species from an examination of the dead wood, this identification needs confirmation before it can be accepted.

Mention is made in the ancient records[17] of (*a*) the employment of ebony in Egypt for making chests, coffins, a harp and shrines; (*b*) a

[1] J. H. Breasted, *op. cit.*, II, 474. [2] II, 494, 502, 514.
[3] I, 336. [4] II, 375. [5] II, 265, 272, 486. [6] II, 652.
[7] J. L. Burckhardt, *Travels in Nubia*, 1819, p. 313.
[8] E. Naville, *The Temple of Deir el Bahari*, III, p. 15. [9] III: 97.
[10] I: 3. [11] XVII: 2, 2. [12] XII: 8. [13] XXIV: 52. [14] I: 129.
[15] G. Beauvisage, *Le bois d'ébène*, in *Recueil de travaux*, XIX (1897), pp. 77–83.
[16] L. Borchardt, *Das Grabdenkmal des Königs Nefer-ir-ke-Re*, p. 68.
[17] J. H. Breasted, *op. cit.*, V (Index), p. 121.

shrine, statues, staves and whips of ebony, though whether made in the country or not is not stated; and (*c*) ebony chairs and ebony statues as spoils of war. Most of these kinds of ebony objects, except coffins and harps, have been found in graves, the statues, however, being very small. In the tomb of Tut-ankhamun the ebony objects included a bed, bolts for shrine doors, a chair and the legs of a second one, the framework of boxes, a stand for a gaming board, a stool and veneer and inlay.[1, 2]

Amenophis III sent four ebony beds, an ebony head-rest, ten ebony footstools and six ebony chairs to the king of Babylonia and thirteen ebony chairs and one hundred pieces of ebony to the king of Arzawa.[3]

One great use of ebony in Egypt was as veneer and inlay (generally in conjunction with ivory) for the ornamentation of furniture, boxes and other objects.

Small ebony objects (tablets and part of a cylinder seal) are known from the First Dynasty,[4] though the first mention of the wood that can be traced in the Egyptian records is in the Sixth Dynasty.[5] From the Eighteenth Dynasty there is a small head of Queen Tyi[6] and of the same date is an ebony panel, which formed part of a shrine.[7] A specimen of ebony identified as *Dalbergia melanoxylon* was found at Karanis in the Fayum dating from the period 3rd to 5th century A.D.[8]

Elm

The specimens of elm referred to were two pieces from one of the chariots of Tut-ankhamun (one from a wheel and one from the body) and also two other pieces (found on the floor) from another chariot from the same tomb, which were either from the axle or from the pole, and probably from the pole. The species of elm could not be identified. Elm is also known from another Egyptian chariot of the same dynasty now at Turin,[9] where it is reported as having been used for both the pole and the axle, the use of elm for the axle, however, being doubted by Schäfer, who states that it is unsuitable for this purpose.

[1] Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I, pp. 113 114, 115, 119, 203.

[2] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, pp. 31, 33; III, pp. 130, 232.

[3] S. A. B. Mercer, *The Tell-el-Amarna Tablets*, I, pp. 17, 185.

[4] W. M. F. Petrie, (*a*) *The Royal Tombs*, I, pp. 11, 22, 40; (*b*) *The Royal Tombs*, II, p. 22.

[5] J. H. Breasted, *op. cit.*, I, 336.

[6] L. Borchardt, *Der Porträtkopf der Königin Teje.*

[7] E. Naville, *The Temple of Deir el Bahari*, III, Pls. XXV–XXIX.

[8] Kindly communicated by Mr. S. Yeivin.

[9] H. Schäfer, *Armenisches Holz in altägyptischen Wagnereien*, Berlin, 1931.

Elm is still employed by the modern wheelwright. The common elm (*Ulmus campestris*) is widely distributed in Europe and Asia, including western Asia, Asia Minor and northern Palestine, from one of which places it doubtless reached Egypt, since there is no doubt that, although chariots in Egypt were originally importations from Asia, they were being made in the country during the Eighteenth Dynasty, this industry being pictured on the walls of several tombs of that period,[1] and, during the reign of Solomon, chariots were imported into Palestine from Egypt.[2]

Fir

Two of the specimens of fir examined are stated to be probably the Cilician fir (*Abies cilicica*), which grows in Asia Minor and Syria.[3] The species of the third specimen could not be determined. A papyrus dated 256 B.C. refers to the planting of 300 fir trees in Egypt.[4]

Hornbeam

This tree (*Carpinus Betulus*) is a native of Europe and western Asia. The wood is whitish, very hard, close-grained and heavy. Ridgeway, as quoted by G. Clark, states that it was used for the yoke of the Eighteenth Dynasty Egyptian chariot in the Museum at Florence.[5]

Juniper

The juniper, of which there are a number of different species, is a tree with a fragrant red wood, which is, and apparently always has been, confused with the cedar and was so confused by the Greeks[6] and Romans.[6] The particular species of juniper represented by the specimens could not be determined with certainty, though in the case of that from the Third Dynasty, which was from the plywood coffin found at Saqqara[7] it is suggested that it may be *Juniperus phœnicea*.[8]

[1] J. G. Wilkinson, *The Manners and Customs of the Ancient Egyptians*, I, (1878), pp. 227, 232; Figs. 60, 64, 65.

[2] 1 *Kings*, 10: 29; 2 *Chron.*, 1: 17.

[3] See Resins, p. 369.

[4] C. C. Edgar, *Zenon Papyri*, II, No. 59157.

[5] See Ash, p. 490.

[6] A. Lucas, '*Cedar*'*-tree Products employed in Mummification*, in *Journal of Egyptian Archaeology*, XVII (1931), pp. 13–21.

[7] J. P. Lauer, *Fouilles du Service des Antiquités à Saqqarah*, in *Annales du Service*, XXXIII (1933), pp. 163–5; Fig. 5; Pl. II.

[8] A. Lucas, The Wood of the Third Dynasty Plywood Coffin from Saqqara, *Annales du Service*, XXXVI (1936), pp. 1–4.

Twigs of *J. phœnicea* found in the Graeco-Roman cemetery at Hawara are in the Museum of the Royal Botanic Gardens, Kew.[1]

The juniper is very plentiful on the Syrian mountains, but it is found also in Asia Minor. From inquiries made there would seem to be in Syria at the present time only one kind of juniper (*J. excelsa*) that grows to the dimensions of a tree, which it is stated may reach a height of between 60 and 70 feet (about 20 metres), the other kinds of juniper being only bushes.[2]

Lime

The lime tree is a native of middle and southern Europe, from where the wood might easily have reached Egypt. In view, however, of the identification by Newberry[3] of two flowers of *Tilia europoea* (fragile and short lived objects that are most unlikely to have been imported) among the vegetable remains from the Graeco-Roman cemetery at Hawara, it seems probable that one or more specimens of the tree may have been cultivated in the Fayum province of Egypt at a late period and, therefore, that the small piece of wood examined (a mummy label) may have been of local origin.

Liquidambar

This tree (*Liquidambar orientalis*), which grows in Asia Minor, has long been familiar in connexion with ancient Egypt on account of its producing a balsam (storax),[4] which was used in perfumery and in embalming, but, so far as is known, only one specimen of the wood has been found, namely a piece from the tomb of Tut-ankhamun (Eighteenth Dynasty). The specimen, which was identified at the Royal Botanic Gardens, Kew, as *Liquidambar sp.*, probably *orientalis*, was about seven inches (18 cm.) long with an almost square section (0.3 × 0.4 inch—8 × 10 mm.). One end is shaped like the cutting end of a chisel and the other end is square. In the tomb records there is no reference to this, from which it is probable that it was found on the floor, its connexions and purpose being unknown.

[1] No number visible; marked 1888 from W. M. F. Petrie.

[2] See also *Official Guide No. 4* (1919), Royal Botanic Gardens, Kew, p. 47.

[3] P. E. Newberry, *The Ancient Botany*, in *Kahun, Gurob and Hawara*, W. M. F. Petrie, p. 46.

[4] See p. 116.

Oak

L. A. Boodle, formerly of the Jodrell Laboratory, Royal Botanic Gardens, Kew, identified a specimen of wood from one of the dowels of the large gilt shrines that enclosed the sarcophagus of Tut-ankhamun as oak, possibly *Quercus Cerris*.[1] This identification has since been confirmed at Kew and, as was only to be expected, is undoubtedly correct. Other specimens of dowels from the shrines were also kindly examined for me at Kew, and with one exception, which was acacia, they were cedar and sidder respectively. Theophrastus states that the oak grew in the vicinity of Thebes,[2] and Pliny, probably copying him, makes the same statement.[3] Clarke, quoting Ridgeway, says that oak was used for the pole, axle and spokes of the Eighteenth Dynasty Egyptian chariot in the Museum at Florence.[4]

Pine

The specimens of pine wood from ancient Egypt that have been found up to the present are two only, one a trimmed piece of predynastic date and the other from the Third Dynasty plywood coffin found in the step pyramid at Saqqara.[5] The species of the earlier specimen could not be determined, but that from the Third Dynasty is probably *Pinus halepensis*.[6] As the predynastic specimen was found at the same place as some pieces of cedar, a typically Syrian tree, probably it, too, had been brought from Syria, though the pine also grows in Asia Minor and *Pinus halepensis* (the Aleppo or Jerusalem pine) is the commonest pine in the Mediterranean region. Several varieties of pine (*P. Pinea and P. halepensis*) are found in gardens in Egypt, but the pine has never been plentiful.

Yew

The common yew (*Taxus baccata*) grows both in western Asia and in southern Europe, but it was probably from Asia and possibly from the Taurus Mountains that the specimens of this wood found in Egypt were brought, all of which were of fairly early date, two being from the Sixth to Twelfth Dynasty and the third from the Eighteenth Dynasty.

[1] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 39; III, p. 153.
[2] *Enquiry into Plants*, IV: 2, 8. [3] XIII: 19. [4] See Ash, p. 490.
[5] J. P. Lauer, *op. cit.*, pp. 163–5; Fig. 5; Pl. II.
[6] A. Lucas, *Annales du Service*, XXXVI (1936), pp. 1–4.

The yew is one of the few conifers that do not produce resin and, therefore, it cannot possibly be the ancient *ach*, as suggested by Ducros,[1] the resin from which was as important as the wood.

Egyptian Timber

Trees are often depicted on the walls of tombs and temples, but they are usually drawn in so conventional a manner that only very few can be recognized with certainty, namely, the acacia,[2] the date palm, the dom palm and the sycamore fig. The principal trees that grew in Egypt in dynastic times of which the timber was employed by the carpenter and joiner were acacia, sycamore fig and tamarisk, though the wood of other trees was also sometimes used, especially that of the date palm, the dom palm, the sidder (*nabḳ*), the persea and the willow. The following list shows all the recent identifications by modern methods of Egyptian woods that can be traced:

Wood	*Date*	*Object*
Acacia	Predynastic period	Log[3]
Acacia	Predynastic period	Roots[4]
Acacia	About IIIrd Dynasty	Beam[5]
Acacia	Vth Dynasty	Tree trunk[6]
Acacia	VIth to XIIth Dynasty	Coffin peg[7]
Acacia	XIIth Dynasty	Coffin peg[8]
Acacia	XVIIIth Dynasty	Two pegs[9]
Acacia	XVIIIth Dynasty	Dowel[10]
Acacia	1st century B.C. (?)	Boning rod[11]
Acacia	Late	Peg from box[5]
Acacia	Roman	Mummy label[5]
Almond	XVIIIth Dynasty	Walking stick handle[12]
Carob	Middle Kingdom	Bow[12]
Persea	New Kingdom	Head-rest[5]

[1] H. A. Ducros, *Annales du Service*, XIV (1914), pp. 1–12.
[2] Excellent representations of acacia trees occur in a Twelfth Dynasty tomb at Beni Hasan (F. Ll. Griffith, *Beni Hasan*, IV, Frontispiece, Pls. VI, VII).
[3] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 95.
[4] Sir R. Mond and O. H. Myers, *Cemeteries of Armant I*, p. 7.
[5] W. Ribstein, *ibid.*
[6] L. Borchardt, *Das Grabdenḳmal des Königs Neferirkeḳ-Re*, p. 43.
[7] G. Beauvisage, *Recueil de travaux*, XVIII (1896), p. 85.
[8] M. A. Murray, *The Tomb of Two Brothers*, p. 11.
[9] L. Borchardt, *Der Porträtḳopf der Königin Teje*, p. 11.
[10] Identified at the Royal Botanic Gardens, Kew.
[11] K. P. Oakley, *The Analyst*, LVII (1932), p. 159
[12] In the Museum, Royal Botanic Gardens, Kew (No. 61/1923).

Wood	*Date*	*Object*
Sidder (*Nabḳ*)	IIIrd Dynasty	Coffin[1]
Sidder (*Nabḳ*)	XVIIIth Dynasty (Tut-ankhamun)	Dowels[2]
Sidder (*Nabḳ*)	XVIIIth Dynasty (Queen Tiy)	Dowels[3]
Sidder (*Nabḳ*)	Roman	Mummy label[4]
Sidder (*Nabḳ*)	Undated	Peg[4]
Sycamore fig	Predynastic	Roots[5]
Sycamore fig	Vth Dynasty	Vases[6]
Sycamore fig	XIth Dynasty	Roots[7]
Sycamore fig	XIIth Dynasty	Coffins[8]
Sycamore fig	Probably XIIth Dynasty	Coffin[9]
Sycamore fig	XIIth Dynasty	Coffin[10]
Sycamore fig	XIIth Dynasty	Statuette[10]
Sycamore fig	XVIIIth Dynasty	Model building cradles[10]
Sycamore fig	XXth to XXVIth Dynasty	Coffin[2]
Sycamore fig	Very late	Eight specimens[4]
Tamarisk	Late Quaternary period	Stems and branches[11]
Tamarisk	Badarian period	Pieces[12]
Tamarisk	Predynastic period	Pieces[13]
Tamarisk	XIth Dynasty	Roots[7]
Tamarisk	Middle Kingdom	Walking stick and throw stick[14]
Tamarisk	XVIIIth Dynasty	Foot of pall support[15] and throw stick[3]
Tamarisk	XXth to XXVIth Dynasty	Coffin pegs[2]
Tamarisk	XXth to XXVIth Dynasty	Coffin[2]
Tamarisk	Roman	Five specimens[4]
Willow	Protohistoric	Knife handle[16]
Willow	IIIrd Dynasty	Box[4]
Willow	Greek	Tent pole[17]
Willow	Roman	Mummy label[4]

[1] Identified by Dr. L. Chalk. See A. Lucas, *Annales du Service*, XXXVI (1936), pp. 1–4.

[2] Several specimens identified by Dr. L. Chalk (The Imperial Forestry Institute, University of Oxford, *Eighth Annual Report*, 1931–2, p. 11); a number of other specimens identified by me.

[3] Identified by Dr. L. Chalk. Three other specimens were identified at a later date at the Royal Botanic Gardens, Kew.

[4] W. Ribstein, *ibid.*

[5] Sir R. Mond and O. H. Myers, *Cemeteries of Armant*, I, p. 7.

[6] L. Borchardt, *Das Grabdenkmal des Königs Nefer-ir-ke-Re*, pp. 60–2.

[7] H. E. Winlock, *The Egyptian Expedition, 1921–1922, Bull. Met. Mus. of Art, New York*, II (1922), pp. 26–8.

[8] M. A. Murray, *The Tomb of Two Brothers*, p. 11.

[9] G. Beauvisage, *Annales de la Société botanique de Lyon*, XX (1895), p. 2.

[10] K. P. Oakley, *The Analyst*, LVII (1932), p. 159.

[11] K. S. Sandford, *The Pliocene and Pleistocene Deposits of Wadi Qena*, in *Quart. Journ. Geological Society*, LXXXV (1929), p. 503.

[12] G. Brunton and G. Caton-Thompson, *op. cit.*, p. 38.

[13] *Id.*, p. 62.

[14] In the Museum, Royal Botanic Gardens, Kew (No. 61/1923).

[15] Identified by Dr. L. Chalk (The Imperial Forestry Institute, University of Oxford, *Ninth Annual Report*, 1932–3, p. 12).

[16] G. Moller and A. Scharff, *Das vorgeschichtliche Gräberfeld von Abusir El-Meleq*, p. 47.

[17] C. C. Edgar, *Zenon Papyri*, III (1928), No. 59253, pp. 80–1.

The various woods mentioned may now separately be considered.

Acacia

A number of different varieties of acacia grow in Egypt and the wood has been identified as having been used as early as the predynastic period.

Acacia is mentioned in the ancient records as having been obtained in the Sixth Dynasty from Hatnub[1] in Middle Egypt and from Wawat[2] in Nubia and to have been used for making boats[1, 2, 3] and warships.[4] Herodotus states[5] that acacia wood was employed in Egypt, not only for boat building, but also for the masts; Theophrastus says[6] that the acacia was an Egyptian tree used for roofing and for the ribs of ships; Strabo refers[7] to the Thebaic acacia; Pliny, apparently quoting Theophrastus, mentions[8] an Egyptian thorn, evidently the acacia from the description, that was used for making the sides of ships, which tree he states grew in the vicinity of Thebes, and Dioscorides says that the acacia grew in Egypt.[9] Acacia is still used in Egypt for boat building as well as for other purposes.

Almond

The almond tree has been discussed already in connexion with almond oil.[10] The one specimen of this wood known from ancient Egypt was found in a tomb at Thebes dating from about 1500 B.C.[10]

Carob

The carob, or locust-bean tree (*Ceratonia Siliqua*), is a native of south Europe and the Mediterranean region. Theophrastus states[11] that 'some call it the Egyptian fig—erroneously; for it does not occur at all in Egypt, but in Syria and Ionia and also in Cnidos and Rhodes.' Pliny copied Theophrastus.[12] Strabo says[13] that carob trees are found in abundance in Ethiopia.

According to Breasted[14] a chest of carob wood is mentioned in the Sixth Dynasty and carob wood and objects made from the wood were brought to Egypt from Arrapachitis,[15] Assur,[16]

[1] J. H. Breasted, *Ancient Records of Egypt*, I, 323. [2] I, 324.
[3] IV, 229, 283, 387, 916, 1023. [4] IV, 229, 387. [5] II: 96.
[6] *Enquiry into Plants*, IV: 1, 2, 8. [7] XVII: 1, 35. [8] XIII: 19.
[9] I: 133. [10] See p. 381.
[11] IV: 2, 4. [12] XIII: 16. [13] XVII: 2, 2.
[14] J. H. Breasted, *op. cit.*, I, 372.
[15] J. H. Breasted, *op. cit.*, II, 512. [16] J. H. Breasted, *op. cit.*, II, 449.

Retenu,[1] and Zahi,[2] the objects being chairs, a table, a shrine, a staff and chariots, and carob wood was imported during the Twentieth Dynasty.[3]

Loret states[4] that the fruit of the carob tree is known from Egypt from the Twelfth Dynasty; Bruyère found it from the Eighteenth Dynasty[5] and Newberry identified one pod and six seeds of Twelfth Dynasty date from Kahun and two pods and several seeds from the Graeco-Roman cemetery at Hawara.[6] A simple bow of carob wood from Thebes, dating from about 1700 B.C., presented by Newberry is in the Museum of the Royal Botanic Gardens at Kew.[7]

At the present time the only carob trees that can be traced in Egypt are a number of scattered ones growing along the north coast all the way from Alexandria to Sollum.[8]

Zaki Yusef Saad suggests[9] that inscriptions on two pottery jars from the First Dynasty tomb of Hemaka at Saqqara refer to carob, and, if so, the fruit would probably be meant.

Date Palm

The date palm (*Phœnix dactylifera*) has been cultivated in Egypt from very remote times and is often represented on tomb walls, for example, in a number of Eighteenth Dynasty tombs in the Theban necropolis.

The wood of the date palm, on account of its loose fibrous texture, is quite unsuitable for joiners' work, but the split trunk of the tree was employed anciently for roofing, as it still is occasionally at the present day, since a tomb of the Second or Third Dynasty at Saqqara was roofed with palm logs[10]; in a tomb of early date at Gau[11] near Asiut, in a Fourth Dynasty tomb adjoining the pyramid of Chephren and in the Fifth Dynasty tomb of Ptahhotep at Saqqara a roof of this kind has been copied in stone. In the Graeco-Roman city of

[1] J. H. Breasted, *op. cit.*, II, 436, 447, 491, 509, 525.
[2] J. H. Breasted, *op. cit.*, II, 490. [3] J. H. Breasted, *op. cit.*, IV, 391.
[4] V. Loret, *Recueil de travaux*, XV (1893), p. 111.
[5] B. Bruyère, *Les fouilles de Deir el Médineh (1934–1935)*, p. 108.
[6] P. E. Newberry, The Ancient Botany, in *Kahun, Gurob and Hawara*, W. M. F. Petrie, pp. 47, 48, 50.
[7] No. 61/1923.
[8] Communicated by Mr. G. W. Murray.
[9] W. B. Emery, *The Tomb of Hemaka*, p. 51.
[10] J. E. Quibell, *Excavations at Saqqara (1912–1914)*, p. 21.
[11] Villiers Stuart, *The Funeral Tent of an Egyptian Queen*, p. 83.

Karanis in the Fayum palm wood was employed in the houses,[1] in the form of trunks sawn longitudinally into long or short beams (of semi-circular cross-section) used mainly for roofing.[2]

Miss Caton-Thompson and Miss Gardner found fruit stones of a wild date (*Phœnix sylvestris*) of early Upper Paleolithic times in a deposit of late Pleistocene age in the Kharga Oasis.[3]

Dom Palm

The dom palm (*Hyphæne thebaica*) is represented in an unmistakable manner in several Eighteenth Dynasty tombs in the Theban necropolis. Theophrastus, who states that the dom palm was an Egyptian tree,[4] comments upon the characteristic bifurcation of the trunk, which in the palm family is exceptional, and he contrasts it with the undivided trunk of the date palm; he describes the wood as being very compact and hard and, therefore, very different from that of the date palm, and states that it was employed by the Persians for making the feet of couches. Delile states[5] that the wood was used in Egypt at the time he wrote (1809) for making doors and, probably, therefore, it was sometimes employed anciently by the carpenter and joiner.

The dom palm does not grow in Lower Egypt, and probably never did: it still grows, however, in Upper Egypt from about Abydos southwards and the fruit is a very common object in graves and has been found from as early as the predynastic period.[6]

Persea

The persea tree (*Mimusops Schimperi*) is referred to in the ancient records from the Eighteenth Dynasty onwards[7, 8] and is mentioned by several of the classical writers. Thus Theophrastus[9] describes it as an Egyptian tree that grew in abundance in the Thebaid; he states that it was evergreen (which it is) and that the wood, which was strong

[1] A. E. R. Boak and E. E. Peterson, *Karanis*, p. 52.
[2] Kindly communicated by Mr. S. Yeivin.
[3] G. Caton-Thompson and E. W. Gardner, *The Prehistoric Geography of Kharga Oasis*, in *The Geographical Journal*, LXXX (1932), p. 384.
[4] IV: 2, 7.
[5] M. Delile, in *Description de l'Égypte, Histoire naturelle*, I (1809), p. 54.
[6] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 63.
[7] J. H. Breasted, *op. cit.*, II, 298; IV, 288, 385.
[8] A. Erman, *The Literature of the Ancient Egyptians*, trans. A. M. Blackman, pp. 159, 160, 246.
[9] IV: 2, 1, 5, 8.

and black, like that of the nettle tree, was used for making images, beds, tables and other objects. Dioscorides states[1] that the persea was an Egyptian tree, bearing an edible fruit that was good for the stomach. I fortunately had an opportunity of examining this wood when a persea tree, planted by Schweinfurth in the garden of the Cairo Museum, was being trimmed, and found that it was very light brown, almost white, in colour with a very slight yellowish tint and that, although it darkened a little on exposure, it did not become more than brown. Pliny[2] states that the persea was an Egyptian tree and he mentions a confusion existing in his day between the persea and the *persica* (peach).

Twigs and leaves of persea have been found in tombs of various dates from the Twelfth Dynasty[3] to Graeco-Roman times and in the tomb of Tut-ankhamun (Eighteenth Dynasty) there were bouquets (several very large) made of twigs with leaves,[4, 5] also dried fruit and two glass models of the fruit. Other examples from this same dynasty are also known.[6, 7] The head-rest identified by Ribstein as being made of persea wood was of New Kingdom date.

Sidder

As there are various species of sidder, and as it is difficult or even impossible to identify closely related species from the anatomical features seen in a microscopical section of the wood, the specimens found to be sidder may be one of several kinds, though from collateral evidence they are practically certainly either *Zizyphus mucronata* or *Zizyphus spina Christi* and probably the latter.

The first of the two sidders mentioned (*Z. mucronata*) is very widespread in Africa, being common all over the drier parts of tropical and south Africa, including the Sudan, and, therefore, it might have been used in ancient Egypt, though this seems improbable, unless it then grew in the country, for which there is no evidence, since the only woods that were brought into Egypt from the south, of which there are records, were ebony and certain sweet and fragrant woods,

[1] I: 187. [2] XIII: 17; XV: 13.

[3] P. E. Newberry, (*a*) *Extracts from my Notebooks*, in *Proc. Soc. Bibl. Arch.*, XXI (1899), p. 304; (*b*) in *Kahun, Gurob and Hawara* (W. M. F. Petrie), p. 49; (*c*) in *Hawara, Biahmu and Arsinoe* (W. M. F. Petrie), pp. 48, 53.

[4] Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen*, I, Pl. XXVII.

[5] Howard Carter, *The Tomb of Tut-ankh-Amen*, II, p. 33.

[6] H. E. Winlock, *The Tomb of Meryet-Amûn at Thebes*, p. 62.

[7] E. Schiaparelli, *op. cit.*, II, p. 166.

probably for use as incense or for making perfumed ointments. The second species of sidder mentioned (*Z. spina Christi*) grows in the Mediterranean region generally, including Egypt, where it is indigenous, and possibly also in tropical Africa.[1] In Egypt it is called the *nabḳ*, although strictly this is the name of the fruit and not of the tree. The fruit is about the size of a small cherry and not unlike a yellowish-coloured cherry in appearance and it has one stone, not unlike a cherry stone in size and shape. The dried fruit is known in Egypt from predynastic times[2] and has often been found in tombs, for instance in a First Dynasty tomb at Saqqara[3] and in the Eighteenth Dynasty tomb of Tut-ankhamun. This tree, although not large enough to have provided the planks that formed the main parts of the shrines mentioned (those of Tut-ankhamun and Queen Tiy respectively) is sufficiently large to have been used for dowels and, as it grows in the country and is a good hard durable wood, it is not to be wondered at, if the amount of cedar available were not sufficient for all the dowels, that local woods should have been used for most of the remainder. One of the woods used in a Third Dynasty plywood coffin was sidder.[4]

Hamilton states[5] that the timber of the *nabḳ* 'is one of the most serviceable in Egypt, the greater part of the Persian water wheel being made of it,' and as the wood has been found so useful in modern times, it is only reasonable to suppose that it was also employed anciently.

Sycamore Fig

The sycamore[6] fig (*Ficus sycomorus*) which is often called the sycamore and is the sycamore of the Bible, has no connexion with the sycamore of colder climates, which latter is a species of maple (*Acer pseudo-platanus*).

The sycamore fig is referred to frequently in the ancient Egyptian records, thus in the Eighteenth Dynasty[7] and in 251 B.C.[8] sycamore

[1] W. G. Browne (*Travels in Africa, Egypt and Syria*, 1799, p. 270) states that he found two species of sidder in Darfur, one of which appeared to be the same that he had seen in Alexandria.

[2] W. M. F. Petrie, *Prehistoric Egypt*, p. 44.

[3] Zaki Yusef Saad, *The Tomb of Hemaḳa* (W. B. Emery), p. 52.

[4] See p. 512.

[5] W. Hamilton, *Remarks on Several Parts of Turkey, I, Ægyptiaca*, 1809, pp. 71, 424.

[6] The New Oxford Dictionary states that the spelling sycamore is more usual than sycomore.

[7] J. H. Breasted, *op. cit.*, II, 326.

[8] C. C. Edgar, *Zenon Papyri*, II, No. 59270.

wood to be used for building a boat is mentioned, and in the Twentieth Dynasty statues of the wood[1] and sycamore gardens[2] are also mentioned. The tree is represented frequently on tomb walls of the Eighteenth Dynasty at Thebes.

Diodorus[3] refers to the sycamore, which he calls the Egyptian fig tree, as growing in Egypt; Theophrastus[4] also describes the sycamore as an Egyptian tree and says that the wood was useful for many purposes; Strabo[5] states that it grew in Ethiopia and Pliny,[6] who quotes Theophrastus, also calls the sycamore the Egyptian fig and states that the wood was among the most useful known.

Either the wood or the fruit of the sycamore fig (which of the two is not stated) has been found in graves as early as the predynastic period,[7] roots from the predynastic period and the fruit from both the predynastic period[8] and the First Dynasty[9]; in the Cairo Museum there are six readily recognized models of the sycamore fig tree in a miniature garden of the Eleventh Dynasty, found by Winlock at Thebes, and Winlock also discovered roots of this same tree in the courtyard of the Eleventh Dynasty temple of Mentuhotep at Deir el Bahari[10]; in the Museum of the Royal Botanic Gardens at Kew there are small branches of Twentieth Dynasty date[11] and, as will be seen from the list given, the wood has been identified in objects varying in date from the Fifth Dynasty to a very late period. The tree still grows plentifully in the country.

Tamarisk

The tamarisk tree, of which there are many species in Egypt, is manifestly indigenous to the country since semi-carbonized stems and branches of considerable size have been found by Sandford in the Wadi Qena,[12] which he attributes to late Quaternary times, and tamarisk wood has been identified from as early as the neolithic,[13] the

[1] J. H. *Breasted, op. cit.*, IV, 303, 349, 395.
[2] IV, 380. [3] I: 3. [4] IV: 2, 1, 2.
[5] XVII: 2, 4. [6] XIII: 14.
[7] W. M. F. Petrie and J. E. Quibell, *Naqada and Ballas*, p. 54.
[8] G. Brunton, *Mostagedda*, p. 91.
[9] W M. F. Petrie, *The Royal Tombs*, II, pp. 36, 38.
[10] H. E. Winlock, *Bull. Met. Mus. of Art, New York*, II (1922), pp. 26, 28.
[11] No. 85/1885.
[12] K. S. Sandford, *The Pliocene and Pleistocene Deposits of Wadi Qena*, in *Quart. Journal, Geological Society*, LXXXV (1929), p. 503.
[13] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 45, 46, 88, 89.

Tasian,[1] the Badarian[2] and the predynastic[2] periods respectively, to as late as Graeco-Roman times, two species, *T. nilotica* and *T. articulata*, having been used at Karanis in the Fayum.[3]

The tamarisk is occasionally mentioned in the ancient records from the pyramid age onwards[4] and bundles of tamarisk wood are referred to in the Twentieth Dynasty.[5] Herodotus states[6] that certain rafts used in connexion with boats were of tamarisk.

Winlock found evidence to show that a grove of tamarisk trees once existed in front of the Eleventh Dynasty temple of Mentuhotep at Deir el Bahari[7]; the tree still grows plentifully in the country.

Willow

The Egyptian willow tree (*Salix safsaf*),[8] whether indigenous or not in the country, is manifestly of considerable antiquity, as the handle of a flint knife of protohistoric date has been identified as willow, another example of its early use being for a box of the Third Dynasty; it was also employed during Graeco-Roman times and is still utilized for making camel saddles, the screw of the Archimedian water elevator and for vine supports.[9] Leaves of the willow tree of Eighteenth and Twenty-first Dynasty date respectively used for making funerary garlands are in the Cairo Museum, some of which are from the tomb of Tut-ankhamun,[10] and in a papyrus dating from 243 B.C. there is a request for willow for making tent poles.[11]

Wood Working

The art of wood carving and the crafts of the carpenter and joiner cannot have been known in Egypt before the late predynastic period, since it was not until then that metal (copper) tools were available, and

[1] G. Brunton, *Mostagedda*, p. 33.
[2] G. Brunton and G. Caton-Thompson, *op. cit.*, pp. 38, 62; G. Brunton, *Mostagedda*, pp. 59, 67.
[3] Kindly communicated by Mr. S. Yeivin.
[4] A. Erman, *op. cit.*, pp. 3, 18.
[5] J. H. Breasted, *op. cit.*, IV, 241, 379, 392. [6] II: 96.
[7] H. E. Winlock, *op. cit.*, pp. 26, 27.
[8] This tree has recently been made the subject of a special study by Dr. L. Keimer (*Bull. de l'Inst. français d'archéol. orientale*, XXXI (1931), pp. 178–227.
[9] Kindly communicated by Professor F. W. Oliver, F.R.S.
[10] P. E. Newberry, Appendix III, *The Tomb of Tut-ankh-Amen*, Howard Carter, pp. 191–2.
[11] C. C. Edgar, *Zenon Papyri*, III, No. 59353.

the few specimens of worked wood of earlier date that have been found must have been fashioned in the very rough manner that alone was possible without metal tools.

Because of the early and constant importation of timber into Egypt it has been stated that wood working cannot have originated in the country, but must have been introduced from abroad. This, however, does not necessarily follow, since there have always been, as there are to-day, plenty of comparatively small indigenous trees, such as acacia, sidder (*nabk*), sycamore fig, tamarisk and willow that could have been used for making boats, boxes, coffins, furniture and other objects, and unless there had been some previous knowledge of wood working, it is difficult to understand why there should have been any demand for wood from abroad. The need was not for timber of any kind, but for timber of better quality and larger size than that obtainable locally.

The tools employed in ancient Egypt by the carpenter and joiner are well known from illustrations of their use pictured on tomb walls, and also from specimens of them, either full size, or miniature, that have been found in tombs. They were adzes, axes, chisels and saws, all, except some of the chisels, having wooden handles; also bow-drills and wooden mallets. At first and for a very long period, the blades were copper, which later gave place to bronze and at a very late date to iron.

The saw may be mentioned specially, as it is of particular interest. Saws are of two kinds, the push-saw and the pull-saw, the former, which is the western type, having the cutting edge of the teeth set away from the handle, the saw being pushed forward in use, while the latter has the cutting edge of the teeth set towards the handle, the saw being pulled. As is shown by Miss M. Lane, it was the pull-saw that was employed in ancient Egypt.[1] From numerous illustrations on tomb walls and from three tomb-models of carpenters' shops in the Cairo Museum, one of Eleventh Dynasty date and two probably from the Old Kingdom,[2] it is seen that the wood to be sawn was tied in the vertical position to an upright post and cut from the top downwards, which is the most convenient position for the pull-saw in contrast to the horizontal position of the wood when a push-saw is used. Also, the tip of the saw is shown pointing upwards, as would be the case with a pull-saw, and both hands are being used, which

[1] M. Lane, The Pull-Saw in Ancient Egypt, *Ancient Egypt and the East*, 1935, pp. 55–8.

[2] Nos. J. 39129 and J. 45319.

again is necessary with a pull-saw. Petrie stated[1] some years ago that the saw dates certainly from as early as the First Dynasty, as from this period there is a wooden coffin showing rough saw marks,[2] and just before the war Emery found seven copper saws in a First Dynasty tomb at Saqqara, which are the oldest and largest known up to the present.[3] The blades of these vary in length from 25.1 to 40.0 centimetres (9.8 to 15.7 inches). In the Cairo Museum there is from the end of the Third Dynasty a section of a trunk of a small tree found by Alan Rowe, on which are ancient saw-cuts and which is labelled 'Section of a log which projected from the wall of the shaft leading up to the burial chamber of the pyramid of Sneferu at Medum.'[4] A small copper saw was found by Firth in a Second Dynasty tomb at Saqqara,[5] and Reisner found one of Old Kingdom date at Giza.[6]

The plane was unknown in ancient Egypt, the wood being smoothed by rubbing it with pieces of fine-grained sandstone, as is shown in the Eleventh Dynasty model carpenter's shop already mentioned.

With respect to the lathe Petrie says[7] 'There was no lathe cutting, even in Roman times; and it is curious that the rings on wooden legs of stools are all hand-worked in imitation of lathe turning'; and in an anonymous review, almost certainly written by Petrie, it is stated[8] that 'the early stool legs are not turned, but hand-worked, yet the pattern is obviously copied from turned work in the XIXth. dynasty. A small box (University College) is clearly turned, of the XVIIIth. or XIXth. dynasty . . .' Wainwright states[9] that 'In every direction in Graeco-Roman Egypt one is met by quantities of turned woodwork, forming the strongest contrast to Pharaonic Egypt.' 'This would imply that the turning lathe was a Graeco-Roman introduction into Egypt.' He also refers to a stool leg of Eighteenth Dynasty date, which de Garis Davies states[10] was 'turned in a lathe,' because there is a pivot hole at the foot, and says[9] 'it seems probable that the work was not so much turned, in our sense of the term, as filed into shape.' Davies also mentions the head of a walking-stick from the Eighteenth

[1] W. M. F. Petrie, *Weapons and Tools*, p. 43.
[2] W. M. F. Petrie and Others, *Tarkhan I and Memphis V*, p. 26, Pl. XXIV.
[3] W. B. Emery, *A Preliminary Report on the First Dynasty Copper Treasure from North Saqqara, Ann. du Serv.*, XXXIX (1939), pp. 427–37. [4] No. J. 57710.
[5] Cairo Museum: not numbered. [6] No. J. 67596.
[7] W. M. F. Petrie, *Social Life in Ancient Egypt*, 1924, p. 153.
[8] *Ancient Egypt*, 1926, p. 55.
[9] G. A. Wainwright, Turnery, etc., from Kom Washim and Gerzah, *Annales du Service*, XXV (1925), pp. 113–9.
[10] N. de G. Davies, *Five Theban Tombs*, pp. 5–6; object No. 5, Pl. XVII.

Dynasty, which he calls a ' piece of turnery,' [1] Legs, ornamented with rings, like modern turnery, occur on a stool from the tomb of Tut-ankhamun, but whether they are turned or filed has not been determined, though it seems probable that the lathe in Egypt may be earlier than was thought.

Illustrations of wood working that may be mentioned occur in a Fifth Dynasty tomb at Saqqara[2]; in a Sixth Dynasty tomb at Deir el Gabrawi[3]; in two Twelfth Dynasty tombs at Beni Hasan[4]; in four Eighteenth Dynasty tombs[5] and in two Nineteenth Dynasty tombs[6] in the Theban necropolis, and in three tomb-models of carpenters' shops already mentioned, the men being shown using miniature tools.

During the Old Kingdom wood working reached a high degree of skill, as is proved, for example, by the carved wooden panels[7] and the six-ply wooden coffin,[8] both of Third Dynasty date from Saqqara; the Fourth Dynasty furniture from the tomb of Queen Hetepheres at Giza[9]; the Fifth Dynasty carved wooden doors from Saqqara[10] and the celebrated wooden statue known as the Sheikh el Beled.[11]

From the Middle Kingdom, examples of woodwork that may be mentioned are the immense cedar coffins and the cedar canopic box of Amenemhet[11]; the ebony and ivory inlaid caskets from Lahun,[12] and the wooden statue of King Hor.[11]

From the Eighteenth Dynasty there are the furniture (chairs, stools, and beds), coffins, boxes and other woodwork from the tombs of Yuya and Thuyu,[13] and Tut-ankhamun.[14]

[1] N. de G. Davies, *Five Theban Tombs,* pp. 5–6; object No. 8, Pl. XVII.

[2] G. Steindorff, *Das Grab des Ti,* Pls. 119, 120, 132, 133.

[3] N. de G. Davies, *The Rock Tombs of Deir el Gabrâwi,* I, Pls. XIV, XV, XVI; II, Pl. X.

[4] P. E. Newberry, *Beni Hasan,* I, Pls. XI, XXIX; II, Pl. XIII.

[5] P. E. Newberry, *The Life of Rekhmara,* Pls. XVII, XVIII; N. de G. Davies, (*a*) *The Tomb of Two Sculptors at Thebes,* Pls. XI, XII, XIII; (*b*) *The Tomb of Neferhotep at Thebes,* I, Pls. V, XXVII; (*c*) *The Tomb of Puyemrê at Thebes,* Pls. XXIII, XXIV.

[6] N. de G. Davies, *Two Ramesside Tombs,* Pls. XXXVI, XXXVIII.

[7] J. E. Quibell, *The Tomb of Hesy,* Pls. XXIX, XXX, XXXI, XXXII.

[8] C. M. Firth and J. E. Quibell, *The Step Pyramid,* p. 42; J-P. Lauer, (*a*) *Annales du Service,* XXXIII (1933), pp. 163–5; (*b*) *La pyramide à degrés,* pp. 60–1; A. Lucas, *Annales du Service,* XXXVI (1936), pp. 1–4.

[9] G. A. Reisner, *Bull. Mus. Fine Arts, Boston,* XXV (1927), Supplement; XXVI (1928), No. 157; XXX (1932), No. 180. The present wood is entirely new, but only replaces old wood that had perished.

[10] No. J. 47749.

[11] Cairo Museum.

[12] A. C. Mace, The Lahun Caskets, *Ancient Egypt,* 1921, pp. 4–6.

[13] J. E. Quibell, *The Tomb of Yuaa and Thuiu.*

[14] Howard Carter and A. C. Mace, *The Tomb of Tut-ankh-Amen,* I; Howard Carter, *The Tomb of Tut-ankh-Amen,* II, III.

It is often assumed that chairs are peculiarly western, but this is not so, their origin being eastern and possibly Egyptian, and from the Fourth Dynasty there is the chair (restored) from the tomb of Queen Hetepheres and the several chairs of excellent design and workmanship from the Eighteenth Dynasty tomb of Tut-ankhamun.

The Third Dynasty plywood coffin mentioned, or rather what remains of it, was discovered in an alabaster sarcophagus in a passage in the step pyramid at Saqqara. The sides, ends and bottom of the coffin (the lid is missing) consisted of six-ply wood, each layer being about four millimetres (0.16 inch) thick, from four to thirty centimetres (1.58 to 11.82 inches) wide and of various lengths. None of the pieces of wood was either broad enough for the height of the sides, nor long enough for the length of the coffin, and in order to obtain the necessary height, width and length, separate pieces of wood were joined together by means of flat wooden dowels, which were held in place with small wooden pegs. The different layers making the thickness were also pegged together, the various layers being arranged with the grain of the wood alternately in different directions, exactly as is done to-day in order to give strength and to prevent warping. At the bottom corners of the coffin the edges of the five outermost layers were bevelled, that is to say the joints were mitred, but the innermost layer had square (butt) joints. The bottom corners were strengthened inside by separate pieces of wood. The outermost layer had a carved ribbed pattern which originally had been covered with sheet gold fastened in place with small gold rivets.

A few features of the early Egyptian woodwork may briefly be mentioned, namely, joints, veneer and inlay.

Joints

Lashing and Pegging. One of the simplest and earliest methods of securing the joints of woodwork was by lashing them with thongs of hide or leather, narrow copper bands, or linen string. Leather thongs were used as early as the First Dynasty.[1] Lashed, as well as other kinds of jointing, occur in the wooden coffins from Tarkhan (Third Dynasty to Eleventh Dynasty), which have been described and illustrated by Mackay.[2] Brunton says[3] of a coffin of the Seventh or

[1] W. B. Emery, *Hor-Aha*, pp. 63–4.

[2] E. Mackay, in *Heliopolis, Kafr Ammar and Shurafa*, W. M. F. Petrie, E. Mackay and Others, pp. 23–30; Pls. XXIV, XXV.

[3] G. Brunton, *Mostagedda*, p. 101.

Eighth Dynasty that 'The . . . corners were held together by ropes running round pegs placed in recesses in the thickness of the wood.' A few special examples of lashing (and in some instances also of pegging and of mitred joints) in the Cairo Museum include the reproductions of the wooden bed-frame and the gold-covered wooden canopy from the Fourth Dynasty tomb of Queen Hetepheres,[1] which have been lashed by Reisner with leather thongs on evidence obtained from the tomb; the huge wooden sarcophagus and the wooden coffin of Amenemhet (Twelfth Dynasty), which have mitred joints lashed with narrow copper bands (6 to 7 mm. wide and 0.6 mm. thick) and also pegged with wooden pegs, and an Eighteenth Dynasty wooden coffin from Deir el Medineh,[2] which has the joints pegged and lashed with linen string.

Mortise and Tenon Joints. These joints were used in the Hetepheres furniture (Fourth Dynasty)[3]; to fasten on the arms of the Sheikh el Beled (Fifth Dynasty); in the Eighteenth Dynasty furniture of Yuya and Thuyu and Tut-ankhamun respectively and in many other instances.

Dove-tailing. This is exemplified in the Hetepheres furniture[4] (Fourth Dynasty); in a large box from the tomb of Tut-ankhamun[5] (Eighteenth Dynasty); in the wooden framework of a tambourine[6] (Eighteenth Dynasty) and in a coffin from Thebes[7] (Eighteenth Dynasty). Petrie states[8] that dove-tailing is known in ivory from the First Dynasty.

Dowels. Flat dowels both of ivory and of wood were used in the First Dynasty,[9] and flat wooden dowels in the Third Dynasty for the plywood coffin already mentioned; also in the Fourth Dynasty Hetepheres furniture, and in the tomb of Tut-ankhamun, especially in the four large shrines that were outside the sarcophagus.

Mitred Joints. These have already been mentioned as occurring early in the Third Dynasty.

[1] G. A. Reisner, *Bull. Mus. Fine Arts, Boston*, xxx (1932), No. 180.
[2] No. J. 66869.
[3] G. A. Reisner, *op. cit.*, xxv (1927), Supplement; xxvi (1928), No. 157; xxx (1932), No. 180.
[4] G. A. Reisner, *op. cit.*, xxv (1927), Supplement, p. 30.
[5] Howard Carter, *The Tomb of Tut-ankh-Amen*, iii, Pl. XXXI (No. 370).
[6] Found at Thebes by A. Lansing, No. J. 66246.
[7] W. C. Hayes, *Bull. Met. Mus. of Art, New York, Egyptian Exped. 1934–1935*, p. 19.
[8] W. M. F. Petrie, *The Royal Tombs*, ii, p. 39.
[9] W. B. Emery, *Hor-Aha*, pp. 63–4.

Veneer

This occurs in the furniture from the tomb of Yuya and Thuyu[1] and Tut-ankhamun respectively. In the former the veneer, which is thick (3 to 4 mm.), is held in place with small wooden pegs, whereas in the latter the veneer is thinner and is glued on.

Inlay

Inlay of ivory and of wood is present on a small wooden box from the First Dynasty tomb of Hemaka at Saqqara,[2] and inlay of wood alone on another box from the same tomb.[2] Ebony inlay occurs on the Hetepheres carrying chair (Fourth Dynasty); ebony and ivory inlay are present on the Lahun caskets[3] (Twelfth Dynasty) and are very common on the objects from the tomb of Tut-ankhamun (Eighteenth Dynasty), particularly fine examples being the carved ivory inlay on a box bearing representations of the king and queen; the ebony and ivory inlay on a large box, on several small boxes and on a stick.

The inlaying of wooden objects, especially coffins and boxes, with coloured stones, faience and opaque coloured glass is very common from the Eighteenth Dynasty, examples being the gilt wooden coffin of Yuya; the coffin lid from the so-called 'Tomb of Queen Tiy' and the middle coffin, the throne and two chariots from the tomb of Tut-ankhamun.

Bark

Bark was much used in ancient Egypt, particularly during the Eighteenth Dynasty, as a decoration for wooden objects, such as the compound bows, walking sticks, fan handles, goads, a bow box and the axle of a chariot from the tomb of Tut-ankhamun, and sticks, bows and chariots from other tombs. Hall says[4] 'the wood used in the construction of chariots was foreign . . . while the bark of the birch-tree served as a decoration. The birch-bark, which must have come (if we rule Italy and Macedonia out) from Anatolia or North Persia, was apparently much admired, and was used to decorate sticks and staves,

[1] J. E. Quibell, *The Tomb of Yuaa and Thuiu*, Nos. 51109, 51110, 51113.
[2] W. B. Emery, *The Tomb of Hemaka*, p. 41.
[3] A. C. Mace, *Ancient Egypt*, 1921, pp. 4–6.
[4] H. R. Hall, *The Cambridge Ancient History*, II, p. 424.

as also was cherry bark, which certainly came from Persia and the Caucasus region.' This identification as birch bark and cherry bark respectively was largely guesswork based on the appearance of the barks in question, though it may be correct, but so far as is known to me, no expert examination has been made. Schäfer thinks that the 'birch' bark employed in Egypt was the inner bark or bast and that it was probably obtained from Armenia.[1]

What is possibly birch bark of neolithic date has been found in the Fayum,[2] and a small roll of bark in the Cairo Museum is described in the register as 'Roll of Birch Bark.'[3] Petrie found at Athribis 'a curious chain made of long strips of bark, coiled round and covered with a vegetable paste . . .'[4] the date of which is unknown, but probably late. Grahame Clark quotes Ridgeway for the statement that birch bast was used for the binding of the Eighteenth Dynasty chariot in the Museum at Florence. Clark adds that birch trees grow in southern Armenia.[5]

Silicified Wood

Silicified, petrified or fossil wood is wood the original substance of which has been removed by natural agencies and replaced by silica in such a manner that the structure of the wood has been preserved. Silicified wood occurs plentifully in Egypt and is widely distributed, being found near Cairo, in both the eastern and western deserts, in the Fayum and in Sinai. Although very hard, this material was employed occasionally for carving and a statuette of it from the Nineteenth Dynasty[6] is in the Cairo Museum and Petrie mentions a scarab of silicified wood, possibly also of Nineteenth Dynasty date.[7] A grinder of this wood is known from the neolithic period[8] and a worked fragment from the Badarian period.[9]

The genera and species of much of this silicified wood have been

[1] H. Schäfer, *Armenisches Holz in altägypischen Wagnereien*, Berlin, 1931.
[2] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 88, 122.
[3] No. J. 48153.
[4] W. M. F. Petrie, *Memphis I*, p. 15; Pl. LI (18).
[5] Grahame Clark, Horses and Battle Axes, *Antiquity*, 15 (1941), pp. 58, 59.
[6] G. Legrain, *Statues et Statuettes*, I, pp. 55–6; Pls. LX, LXI.
[7] W. M. F. Petrie, *Scarabs and Cylinders with Names*, p. 9.
[8] G. Caton-Thompson and E. W. Gardner, *The Desert Fayum*, pp. 32, 87.
[9] G. Brunton and G. Caton-Thompson, *The Badarian Civilisation*, p. 102.

determined,[1-6] but it is unnecessary to quote them here, since none of the kinds of wood is known from historical times.

Charcoal

Charcoal, which may be dealt with conveniently in connexion with wood, was until comparatively recently, when it was largely displaced by paraffin oil (kerosene), the principal fuel of Egypt and it is still much used.

At one time charcoal-burning was extensively carried out in the eastern desert and in Sinai, in both of which localities it still lingers on, though to a very limited extent, and it is this industry that has been largely responsible for the destruction of trees in those districts.

Charcoal has often been found in connexion with ancient Egypt, for example in Badarian and possibly even in Tasian graves[7]; in a First Dynasty tomb at Saqqara[8]; in two of the store rooms of the pyramid temple of Mycerinus (Fourth Dynasty)[9] and in early dynastic tombs at Naga el Deir[10] and it is mentioned as being distributed to the masons who cut the corridors of one of the royal tombs in the Valley of the Tombs of the Kings.[11]

The making of charcoal was a natural outcome of the burning of wood, and the first deliberate making must have been very early in Egyptian history, though the date is unknown. The value of charcoal in the progress of civilization must have been enormous, for without charcoal any advance in metallurgy beyond the most primitive methods would have been difficult, if not impossible.

[1] F. Unger, *Der versteinerte Wald bei Kairo*, 1858.

[2] Krauss and Schenk, quoted by Barron (*The Top. and Geol. of the District between Cairo and Suez*, p. 58).

[3] F. W. Oliver, *Oasis Impressions*, in *Trans. Norfolk and Norwich Naturalists Society*, XIII (1930–31), p. 176.

[4] A. C. Seward, *Leaves of Dicotyledons from the Nubian Sandstone of Egypt*, Geological Survey of Egypt, 1935.

[5] M. M. Ibrahim, The Petrified Forest, *Bull. de l'Inst. d'Égypte*, XXV (1942–43), pp. 159–82.

[6] N. M. Shukri, On the 'Living' Petrified Forest, *Bull. de l'Inst. d'Égypte*, XXVI (1943–44), pp. 71–5.

[7] G. Brunton, *Mostagedda*, pp. 8, 9.

[8] J. E. Quibell, *Excavations at Saqqara (1912–1914)*, p. 15.

[9] G. A. Reisner, *Mycerinus*, p. 238.

[10] G. A. Reisner, *A Provincial Cemetery of the Pyramid Age, Naga-ed-Der*, III, p. 157.

[11] On an ostrakon (No. J. 33857) of Twentieth Dynasty date in the Cairo Museum.

CHAPTER XIX

HISTORICAL SUMMARY[1]

From what is known about a people, to trace their gradual growth from a primitive state to one of advanced civilization is a task for the historian, and I have no intention of trespassing in this matter, but I hope to be pardoned if I endeavour to piece together, very briefly and in a very elementary manner, the most important of the facts recorded and to give some little indication of their bearing upon the condition of the ancient Egyptians and upon their intercourse with other nations.

Ancient Egyptian history, like that of many other countries, may be divided roughly into a Stone Age, a Copper Age,[2] a Bronze Age, and an Iron Age, each in turn gradually giving place to the next. The distinguishing feature of these several periods was not the mere employment of stone, copper, bronze, or iron, as the case might be, since each of these was employed in all the succeeding periods and was even known as a curiosity and occasionally used in the preceding period, but it consisted in the use of the special material, after which it is named, for weapons and tools.

Up to the present time fossil remains of primitive man have not been discovered in Egypt, neither remains of the earlier stages of his development when he was merely the genus *homo* (who probably dates back to the end of the Pliocene period or the beginning of the Pleistocene period, possibly a million years or so ago), nor remains of the later and finished stage of his physical evolution after he had become *homo sapiens* (who is much more recent and possibly not more than fifty thousand years or so old).

The first inhabitants of Egypt of whom there is any knowledge were the Old-Stone Age or paleolithic people. Whence they came and the reason for their coming are unknown, but that they must have originated outside Egypt is 'the cradle of

[1] References previously given have not been repeated.

[2] To group the Egyptian Copper and Bronze Ages together and to call them both the Copper Age, or both the Bronze Age, as is sometimes done, is most misleading.

the human race,' which is not suggested by anyone. Once in the country, however, abundant game and water and a pleasant climate would be sufficient reasons for their remaining. These earliest Egyptians date back from about 12,000 years ago to possibly about 30,000 years ago or earlier.

'The Pleistocene period during which Paleolithic Man hunted along the banks of the Nile and ranged over the surrounding hills and plateaus was a time of copious rainfall in Egypt. The dry wadis of the desert were running streams and the landscapes were pleasantly diversified with forest and grassland over which wandered troops of wild animals. Reaching far beyond its present bounds, the ancestral Nile flowed rapidly over a pebbly bed, augmented on its journey northward by a host of tributaries draining the surrounding country. The Nile of the present day is but "a dwindled shadow of the original river."'[1]

Neither the habitations nor the graves of these people, if they had either, have been discovered, only large numbers of characteristic stone weapons and implements (mostly flint and chert) that have been found in various parts of the country. With these their owners could hunt and fight, and paleolithic man must have been essentially a hunter, depending largely for food on the animals he killed, supplemented by certain fruits, seeds (cereal grain) and roots he found growing wild: he was, therefore, a wanderer and a food gatherer and not a food producer, which means that he was not yet civilized. Since pottery containers or animal skins for water had not yet been invented, paleolithic man could not go very far from his water supply and the range of his wanderings was, therefore, restricted.

The exact manner in which civilization developed in Egypt may never be known, but it seems probable that the first step towards it was taken when a community of the hunting paleolithic nomads (possibly at first only women and young children), driven almost certainly by a gradual diminution of rainfall and a gradual conversion of the hills and plateaux into desert, with a resulting scarcity of game, settled down temporarily near the Nile, or on the borders of the Fayum lake, and there discovered that a constant supply of the grain they were accustomed to gather in a haphazard manner, and which sometimes failed, might be assured by sowing, for almost certainly it was agriculture that first anchored man to one locality by making a

[1] K. S. Sandford and W. J. Arkell, *Paleolithic Man and the Nile Valley in Nubia and Upper Egypt*, p. xv.

permanent hunting life both unnecessary and impossible, thus paving the way for the arts and crafts that are essential to material civilization. All that would have been necessary to have started the ball of civilization rolling would have been for someone, either accidentally or intentionally, to have thrown ripe grain (barley or wheat)[1] on to a patch of mud left bare after the flood water of the river had subsided, and when the grain sprouted (which in Egypt would have been very soon after the sowing) to have realized that it was the direct result of the sowing and that never again need there be any shortage of food, since man had the power to grow it, and grain was a food that could be stored easily in a dry climate like that of Egypt without deteriorating.

But since seeds were falling regularly on the ground and germinating wherever there were plants, and so producing an object lesson in the elements of agriculture, the artificial sowing of seed may surely have originated independently in more than one place and, if so, the initial Egyptian sowing may not have been the first in the history of the world, as suggested by Professor T. Cherry,[2] but merely an independent repetition of what had been done elsewhere under different conditions. Even imported knowledge of grain growing, though improbable, does not seem absolutely excluded, since the paleolithic hunters may have been in touch with kindred in the north, or they themselves may have ranged as far northward as Palestine and Syria, the north-east being the direction where other early civilizations arose. The probability, however, is in favour of agriculture having been practised first in Egypt, since, as pointed out by Professor Cherry, nowhere else in the world do such favourable conditions exist. Thus, the Nile flood, which commences about the beginning of July, subsides in November, and seeds sown, either naturally or artificially, germinate after the summer is over, and so the young plants, which would be killed by the heat of the summer, are able to live and grow. In the case of Mesopotamia, the flood water of the Euphrates and Tigris arrives and subsides earlier than that of the Nile and the conditions for agriculture are, therefore, less favourable since the young plants that sprang up would be scorched by the heat of the summer and would die.

[1] Both barley and wheat have been found in Egypt from the neolithic period, millet not being known until the predynastic period.

[2] T. Cherry, *The Discovery of Agriculture*, in *Proceedings of the Australian Association for the Advancement of Science*, 1921.

With respect to the period when desiccation set in, Sandford states[1] that 'Complete failure of rainfall . . . seems to have started in Nubia and to have spread slowly northward along the Nile. The western plains and plateaus probably lost their surface run off in later Middle Paleolithic times . . .' 'The condition of absolute desert may be of late date near the Nile Valley. In Neolithic times there was a greater freedom of movement west of the Nile, especially in the north, than is now possible and crops were raised on ground now barren.' Sandford also says[1] of Upper Egypt in Middle Paleolithic times that 'No signs of desert-like conditions are to be seen' and that north of Gau 'There is no indication that the rainfall had failed in this part of the Nile Valley' and that 'Man could still wander at will at any rate between the Nile and the Red Sea, and westward beyond Kharga Oasis.'

The increase of population in Egypt ultimately and inevitably led to an extension of the natural irrigation system and land near the river not covered by the annual flood had water conducted to it by artificial channels. It is often assumed that agriculture commenced with artificial irrigation, but this would not have been needed until the settled population in any one district had outgrown the grain supply of the naturally-inundated land of that district, and a very long period may have elapsed between the earliest agriculture in Egypt and any attempt to extend artificially the area of cultivation.

It is suggested sometimes that agriculture may have originated from the practice of either burying wild grain, such as barley, in graves, or of scattering it on the surface of newly-made graves. Though plausible and attractive, this is very improbable with respect to Egypt. Thus, in the neolithic settlement at Merimde, although grain was placed on the body to serve as food for the dead person, there is no record of this grain showing signs of having germinated and, even if exceptionally some of it had commenced to grow, the chance of the young plants reaching the surface of the ground would have been very small. At later periods, too, grain was sometimes placed in graves, but it was usually, if not always, in receptacles, such as baskets or pots, where it had no opportunity of germinating. At Merimde the dead were buried, not in special cemeteries, but among the buildings of the settlement, that is to say on high, dry ground, and when later the burial was at a distance from the houses, in places set apart, these were never, so

[1] K. S. Sandford, *Paleolithic Man and the Nile Valley in Upper and Middle Egypt*, pp. 125–6.

far as is known, in the inundated plain, but always on the edge of the dry desert, and in such cases any grain scattered on the surface of the graves would have stood a very poor chance of survival. It seems improbable, too, that 'graveyard tillage,' as it has been termed, could ever have led to an artificial irrigation system, such as is practised in Egypt and with which the early agriculture in the country seems inseparably bound up.

When once some of the nomad people had become settled in one place, even though at first only temporarily, needs would arise and could be satisfied that either were not felt before, or that were not previously capable of realization. Thus, shelters from the weather would be built; baskets and pots would be made as containers for grain and water respectively; sleeping mats would be plaited; clothing would be woven; food would be cooked; to the growing of grain would be added the growing of flax to make linen, and animals would be tamed and others would be bred in order to secure a constant supply of meat and skins, each advance, however, resulting in a loss of freedom, since hunting as a permanent whole-time occupation is incompatible with civilization as it does not leave any time for the development of arts and crafts. This is what actually did happen, the shadowy Old-Stone Age (paleolithic) people being succeeded (possibly about 12,000 years ago) by the New-Stone Age or neolithic Egyptians, who until recently were as unsubstantial as their predecessors, though their stone weapons and implements were of a more advanced type and the flint industry of Egypt attained an excellence that has never been surpassed, or even equalled, elsewhere. Of these neolithic folk, settlements and cemeteries have been discovered during recent years, which prove that, although still in the Stone Age, that is without any knowledge of metals, they were no longer merely food gatherers, but food producers and that they practised agriculture; domesticated animals; dressed hides; plaited baskets and mats; wove fabrics; made pottery; made bone as well as stone implements; made shell and stone beads and small stone vases, all of which connote some degree of civilization and a more or less settled mode of life. Hunting and fishing, though still carried on, gradually became of secondary importance.

Up to the present only a few neolithic sites have been excavated, of which the three principal are all near Cairo, one (in the Fayum) on a lake about fifty miles to the south-west; another (Merimde) about thirty miles to the north-west near the west bank of the river and the third (Helwan) about twenty miles to the south, also not far from the river,

but on the east bank. The so-called 'Neolithic Site' at Maadi near Cairo is not included, since according to the excavators 'The neolithic settlers at Maadi knew copper very well, and apparently possessed large quantities of it.'[1]

This neolithic existence, slowly and steadily improving all the time, continued for several thousand years and then gradually and automatically came to an end as metals became known and as their use increased, the beginning of the knowledge of metals possibly dating from about 5000 B.C. or some 7,000 years ago.

The use of metals (at the outset copper and gold) was naturally at first only very occasional and was confined to small articles of personal adornment, but later they were employed in greater quantity, gold always chiefly for ornament, and copper for weapons, tools and such household utensils as ewers, basins and dishes; silver and lead also became known, though they were not used to any great extent until a very late period.

Although both copper and gold occur naturally in the metallic state, other things being equal, gold is the more likely to be discovered and used first, partly on account of its occurrence in the form of glittering and attractive yellow particles and partly because of its great malleability, since it is readily shaped into simple ornaments. In Egypt, however, although gold occurred plentifully in certain localities and native copper very rarely, if at all, copper objects have been found of earlier date than those of gold, but the evidence is as yet so scanty that this does not necessarily mean that copper was used first (though this may have been so), since the earliest gold may not have been buried, or, if it was, the graves may have been robbed.

It has been suggested that the earliest copper known was always native metal and in certain countries (notably North America) this was undoubtedly the case; but the use of native copper has not always, if ever, led to the method of producing it from ore and in Egypt there is no evidence whatever of native copper and no need to postulate either its existence or use, since a copper ore (malachite), from which the metal might have been obtained easily and from which it may be proved to have been obtained at an early period, was employed in large amount for painting round the eyes and for producing a blue colour in glaze, at a date not only as early as that of the use of the metal itself but probably earlier.

[1] O. Menghin and M. Amer, *The Excavations of the Egyptian University in the Neolithic Site at Maadi*, p. 48.

Malachite occurs in a number of different localities both in Sinai and in the eastern desert, in the latter of which no date can be fixed for mining before about the Twelfth Dynasty (about 2000 B.C.) but in Sinai there is proof of mining in the First Dynasty (before 3000 B.C.) which was either for copper ore or for turquoise (unfortunately it is not known which) and proof of mining copper ore in the Old Kingdom (about 2980 B.C. to 2475 B.C.) of which period copper slag, chips of ore, broken crucibles and an ingot mould have been found and, since malachite (probably from Sinai) was employed in the Badarian and predynastic periods respectively, it seems likely that mining (which at first would consist merely in the extraction of ore from surface deposits and only later of excavation) dates from these periods. As some slight confirmation of the early date of the Sinai mining is the occurrence of a small proportion of manganese in copper objects of both the middle predynastic period and also of First or Second Dynasty date,[1] which seems to indicate that the ore from which the metal in these cases was derived had been obtained from Sinai, where there are abundant deposits of oxides of manganese in close proximity to the copper ore. The object of middle predynastic date referred to is a large cast axe-head of copper weighing three and a half pounds, and if this were made from Sinai ore, then the copper industry in Egypt was already in an advanced state.

Since metallic copper may be produced from malachite by the very simple process of heating it under certain conditions in a wood or charcoal fire, it is highly probable that the first production of copper was by accident from this ore (the usual ore of surface deposits), the constant use of which would present innumerable opportunities for its accidental heating in such a manner that would produce a small quantity of the metal.

Coghlan states[2] that a camp fire, or 'hole in the ground' fire, contrary to the usual idea, would be unlikely to have led to the first accidental production of metallic copper, and he suggests that this may have occurred either in a pottery kiln, or in connexion with the making of glaze, which he seems to associate wholly with either glazed pottery, or with the Egyptian blue frit. But, glazed pottery is very late in Egypt, faience not being glazed pottery; pottery kilns were not

[1] Probably manganese would be found in other ancient Egyptian copper objects if search were made.

[2] H. H. Coghlan, Some Experiments on the Origin of Early Copper, *Man*, 1939, 92.

known in Egypt until long after the discovery of metallic copper, and glazed frit probably was not known until the Fourth Dynasty. But glazed steatite, glazed solid quartz, and glazed quartz frit (faience) were all known from a very early date and probably the glazing was carried out in a small closed chamber, or kiln, and the glaze was often a blue colour obtained from malachite, a copper ore, and thus all the conditions would have existed for the accidental reduction of the malachite to metallic copper, which makes it probable that metallic copper was an Egyptian discovery.

In the earliest graves in which copper has been found in Egypt it was in the form of small primitive articles, such as beads, pins, rings and needles, and only in graves of later periods were there weapons and tools, that is to say, copper did not appear suddenly in a comparatively highly developed form as would be expected had it been imported, but all the stages of evolution from small and simple objects to larger and more complex ones have been found in proper sequence. This gradual increase in the amount of copper employed and the progressive improvement in the size and nature of the objects made, together with the very early use of malachite, would seem strong indications that copper smelting may have been of Egyptian origin, but Frankfort, while admitting the facts, does not admit the inference and says[1] that ' history is no matter of logic and comparative archæology plainly proves that the opportunity was not grasped and that the use of copper on a considerable scale was due to Asiatic initiative.' The comparatively small amount of copper used in Egypt anciently, compared with present-day requirements, and the not inconsiderable output of the Sinai and eastern desert mines are factors that frequently are not taken sufficiently into account in this matter. However, so much that was unknown and even unsuspected has been discovered during the past few years in Mesopotamia, India and elsewhere that manifestly finality in the knowledge of the various early civilizations has not yet been reached. It may be pointed out, too, that practically nothing is known about ancient copper mining and working in north Persia, or in the regions immediately south of the Caucasus Mountains between the Caspian Sea and the Black Sea, nor in the district south of the Black Sea, in all of which places copper ores are plentiful and in many of which there are ancient mines and slag heaps, neither has there been any systematic archaeological investigation of the ancient Egyptian

[1] H. Frankfort, *Sumerians, Semites and the Origin of Copper-Working*, in *The Antiquaries Journal*, VIII (1928), p. 230, *n.* 1.

copper mines. A great deal, too, depends upon the correct dating of copper objects from different sources, about which there is still dispute. In view of these facts, it is not shirking the difficulty if the question of the origin of copper working is left unanswered for the present.

Closely following and consequent upon the use of copper tools in the late predynastic period was the wonderful stone vase industry, which reached its zenith during the early dynastic period, and nowhere has there been found such a wealth of beautifully made, handsome stone vases as in Egypt, the stones employed including, not only the comparatively soft alabaster (calcite), but hard diorite, granite, quartz, rock crystal, greywacke ('schist') and volcanic rock. Literally thousands of these vases (mostly broken) have been found in early dynastic tombs and in the step pyramid at Saqqara, especially in the latter. In the Third and Fourth Dynasties and the dynasties immediately following came the phenomenal working of stone for building pyramid-tombs and mortuary and other temples, and the oldest and largest stone buildings in the world belong to this date. The hard stone statues, too, of this period have long been a source of wonder and admiration on account of their excellence.

One of the great landmarks in the history of civilization was the discovery of bronze, which displaced copper for many purposes, the Copper Age gradually giving place to the Bronze Age. This alloy, which is a mixture of copper and tin, was first made in western Asia and was used both in Mesopotamia and northern India about 1,000 years before the knowledge of it spread to Egypt. Although there may have been, and probably were, a few sporadic importations of bronze into Egypt, possibly even as early as the Fourth Dynasty, it was not in general use until about the Twelfth Dynasty (about 2000 B.C.) from which period tools and other objects of bronze are known, and the Middle Kingdom, therefore, may be considered as the beginning of the Bronze Age in Egypt.

Whether bronze was ever made in Egypt, or whether the bronze objects found were fashioned from material imported into the country in the form of ingots, is uncertain, but since tin was known in Egypt in the Eighteenth Dynasty (a few objects of this metal and also a small quantity of artificial tin oxide from this period having been discovered) it seems probable that at least from this date onwards bronze was made locally from imported tin. At first the tin required was obtained from western Asia, possibly from near Byblos in Syria, but later this source of supply seems to have failed, probably because

the ore became exhausted, and tin then reached the eastern Mediterranean from western Europe (Brittany, Cornwall and Spain).

The Bronze Age in Egypt lasted about thirteen hundred years and was succeeded by the Iron Age. Iron working, like bronze working, had its origin in western Asia and it did not become an Egyptian industry until more than 2,000 years after its discovery in Asia. The earliest iron objects found in Egypt are a few small beads of predynastic date, the metal of which has been proved by chemical analysis to be of meteoric origin and, therefore, not made by man. Although this was possibly not the only instance of the utilization of meteoric iron by the ancient Egyptians, no others are known, and from the predynastic period until the end of the Eighteenth Dynasty only six specimens of iron objects have been discovered in the country, of which four are probably of later date than that assigned to them by their finders, thus leaving only two, now iron rust, but once iron objects that have been tested and found not to be of meteoric origin. From the tomb of Tut-ankhamun at the end of the Eighteenth Dynasty (about 1350 B.C.) there is an iron dagger (a gift to the king from western Asia) and a few very small typically Egyptian objects, almost certainly made in Egypt either from meteoric iron or from a small piece of imported iron, probably also a present from western Asia. After this there is a gradual increase in the number of iron objects known, but the first group of iron tools yet found dates from about 700 B.C., which may, therefore, be considered as the beginning of the Iron Age in Egypt.

The earliest iron smelting of which evidence has been found in Egypt was at Naucratis in the north-west of the Delta, about the sixth century B.C., but the source of the ore dealt with is not known. Iron ores, however, were mined anciently both in the eastern desert (possibly by the Romans) and also near Aswan.

The first production of iron was almost certainly an accident, possibly due to the use by mistake of iron ore in place of copper ore and there cannot be any doubt that when first obtained the metal was treated in the same manner as copper and bronze in order to shape it, namely by hammering it cold, which naturally was found to be useless. This is likely to have happened many times until by chance the metal was hammered before it cooled, when partial success would have been obtained, and eventually it would have been realized that for complete command over the new metal it must be hammered while red-hot. Also, the only kind of hammer the Egyptians knew until late, apart from wooden mallets, was a stone hammer without handle, with which

it would not have been possible to have beaten red-hot metal. The first iron, however, cannot have been much, if any, improvement over copper and bronze for weapons and tools, since it was less easy to work and it was not any harder than hammered copper and bronze and any cutting edge given to it by hammering would readily have become blunted. Somehow it was discovered eventually that if repeatedly heated in a charcoal fire and well hammered between the separate heatings and cooled by plunging it into water, iron would acquire a hardness superior to that of copper and bronze and it was only at this stage that it became of much practical use. This experience was gained before iron was known to the Egyptians, to whom iron smelting and iron working were probably taught by blacksmiths from Asia.

One important material employed in ancient Egypt was a vitreous glaze, which was used in small amount during the Badarian period to cover objects of stone (steatite), and a little later, during the predynastic period, for coating both steatite and quartz, at which period, too, objects were made of powdered quartz (heated possibly with a small proportion of natron or salt to make the quartz cohere), and these were then glazed. It is to this glazed quartz frit that the name of Egyptian faience is given and the industry became an important one and reached a high state of development at an early date. Until the recent discoveries in northern India, it seemed certain that the invention of glaze and the making of faience had originated in Egypt, but glazed steatite and glazed quartz frit have been found at Mohenjo-Daro, which are dated from about 3000 B.C. to about 2750 B.C., and, although the Egyptian glaze and the Egyptian faience, as yet, have the priority of age by several hundred years at least, and although nowhere was faience made on such a large scale and in such perfection as in Egypt, yet it would be premature to insist on the invention being Egyptian until the possibilities of the Indian civilization have been exhausted, which can only be done by further excavation. In any case, neither the glazing of stone, nor still less the making of such an extraordinary material as faience, are likely to have been invented in more than one place and hence, whichever of the two civilizations is the older, there must have been intercourse between them unless both derived the knowledge from some still earlier common source. In Mesopotamia faience apparently was not as old and never of such importance as in Egypt.

A very important outcome of glaze was glass, which is merely glaze used as a separate material instead of as a coating on other materials. The evolution from glaze to glass, so far as can be judged from the

known evidence, took a very long time, a likely reason for this being the conservatism of the glaze worker, who, like artisans of all ages and particularly of early times, would naturally have been averse to new methods and non-receptive of fresh ideas. Although glaze, while in the crucible ready for use, or even if it fell upon the floor, was glass, the worker would have been so occupied with glazing, and research being so foreign to his nature that any experiments respecting new possibilities for his material would not have occurred to him and any development would have been delayed until there happened to have been a glaze worker, with the special inquiring turn of mind that is so rare even to-day, and then some considerable time must have elapsed before the experience necessary for the manipulation of the material on the new lines could have been acquired. Although doubtless originating, as suggested, as a development of glaze, glass making would soon have branched off as a separate industry.

The early history of glass and its country of origin are obscure. One archaeologist is very emphatic about Syria being the home of glass making and that the outburst of glass working in Egypt in the early Eighteenth Dynasty was due to the introduction of Syrian workmen after the Egyptian conquests in Asia.[1] But, although glass making may have been a Syrian industry before about 1500 B.C. (as it certainly was much later during the Arab period when Tyre, Tripoli, Damascus and Aleppo were all noted for their glass) no proof of this can be found and no glass making centres in Syria of such an early date are known. A lump of blue glass, now in the British Museum, found in Mesopotamia, 'which must be at least as early as 2200 B.C. and is probably older,'[2] is not part of an object and, although as it now exists it is glass, it may possibly have been made as glaze, before glass was being used for separate objects. It was found by itself and no other glass is known from the same site. The finder says[2] 'There is of course nothing to show that this isolated fragment of glass was made at Eridu or in Mesopotamia at all—it might be an importation from Egypt. . . . This piece of glass may merely show that the invention had reached Babylon at least as early as 2200 B.C., though it certainly was rarely used there, or we must have found examples of its use as inlay, etc. on the other sites of that period.' In the published description of 'The Royal Cemetery' at Ur by Woolley, glass is not mentioned in the Index, but in the chapter on beads it is stated that there are two instances of 'glass

[1] W. M. F. Petrie, *Descriptive Sociology, Ancient Egyptians*, p. 187.
[2] H. R. Hall, *A Season's Work at Ur*, pp. 213–4.

paste,' whatever that may be, in both the predynastic cemetery and in the much later Sargonid period. A more recent discovery is a small cylinder of clear glass from Tell Asmar, which is dated about 2600 or 2700 B.C.[1]

With respect to India, it is stated[2] that 'no true glass has yet been found either at Harappa or Mohenjo-Daro,' though there is a material the outward resemblance of which 'to an opaque glass is very close' and 'to the casual eye resembles an opaque glass,' but 'the granular nature of its paste proves it definitely not to be glass.'

In Egypt, omitting three instances of glass, which the finders claim to be predynastic, but the dating of which is disputed, and one example from the First Dynasty, which is not glass, but faience, glass is not known before the Fifth Dynasty, from which period there are beads and tiny amulets. From this time onwards there was a gradual increase in the amount of glass until the Eighteenth Dynasty, when there was a sudden burst of glass-making on a large scale. On present knowledge, therefore, glass is an Egyptian invention.

If there had been an early flourishing glass industry in Syria, as is sometimes stated, it is very remarkable that no evidence of it can be traced and also that the product was not imported into Egypt in considerable quantity. It may be mentioned also that the large use of glass inlay in the Eighteenth Dynasty for coffins, boxes, furniture and other objects appears to be typically Egyptian and was merely an extension of the much earlier use of inlay of coloured stones, rendered possible by the invention of glass made to imitate the stones previously employed, which were not available in the required quantity.

Inventions that are generally admitted to be of Egyptian origin are the use of papyrus as a writing material; mummification and the mural painting in tombs and temples.

Although Egypt is somewhat isolated geographically and was still more isolated anciently, on account of the very considerable difficulties of communication that then existed, and although it was largely self-contained and needed no outside help for the necessaries and little for the luxuries of life, yet it was not cut off absolutely from the rest of the world, and two important examples of the result of intercourse between Egypt and its neighbours, namely bronze and iron, have already been mentioned. But, in addition to these, other foreign

[1] H. Frankfort, *Iraq Excavations of the Oriental Institute 1932–33*, pp. 56–8.

[2] E. Mackay, in *Mohenjo-Daro and the Indus Civilization*, Sir John Marshall, pp. 576, 578, 582.

articles found their way into Egypt, though, until a late period, such imports were few in number, the greater proportion of the materials used being of local origin. Thus the building materials, brick, stone, mortar and plaster, were all local; glaze, glass and pottery (wherever they may have originated) were all made in the country from native materials; the metals gold and silver and their alloy electrum, as also the ores of copper and lead from which these two latter metals were produced all occurred in the country; the animal fats and beeswax were native products; the pigments were almost entirely naturally occurring materials, or were made from such materials; the precious and semi-precious stones employed, with two exceptions (jade, of which only about two examples are known, and lapis lazuli) were of local origin, as were also the ornamental and monumental stones (except obsidian); the textile fabrics were woven in Egypt and baskets, ropes and mats were made from fibres that grew in the country; the skins made into leather were local and most of the dyes with which the textile fabrics and the leather were coloured were probably Egyptian; and the food-stuffs (chiefly cereals, green vegetables, oil,[1] fruit, honey, meat and fish) were all produced in the country.

The principal materials imported into Egypt may now be considered, but especially those received up to the early part of the Eighteenth Dynasty, about which period began a much greater intercourse between Egypt and other nations, largely as a result of the Egyptian conquests in Asia, the natural effect of which was a considerable increase in the import of commodities from abroad, which included a number of articles received as tribute or taken as the spoils of war.

The imports were almost entirely either from western Asia, or from Nubia and the Sudan, and to what extent materials were ordinarily received from the countries to the west of Egypt is not known, though this was certainly not an important source of supply.

The principal materials received from Asia before the beginning of the Eighteenth Dynasty, taking them in alphabetical order, were bronze, and possibly also tin for making bronze, from the Middle Kingdom onwards; lapis lazuli, continuously in small amount from predynastic times; obsidian (the total amount of which was not great) from predynastic times; oil, probably chiefly olive oil, from the early dynastic period onwards; resins and wood continuously from the predynastic period.

[1] A small amount of oil for special purposes was imported.

From about the middle of the Eighteenth Dynasty a number of new materials began to be imported into Egypt from Asia, the principal of which were copper, which up to about this date had probably been produced largely from local ores; iron in the form of a few small objects with probably also a very small amount of metal, the amount gradually increasing until iron began to be smelted in the country; orpiment during the Empire, as also varnish or varnish resins, the import of which latter continued until about the Twenty-sixth Dynasty, when it practically ceased.

The materials received from, or through, Nubia and the Sudan were chiefly ebony, gold, ivory, ostrich feathers, leopard skins, fragrant gum-resins and fragrant woods. It is worthy of note that, so far as is known, there was not any material used in ancient Egypt until about the Eighteenth Dynasty that can be traced to India, though India and Ceylon possessed, among other commodities, precious and semi-precious stones and odoriferous resins and fragrant woods, materials that were in great demand in Egypt and that are of small bulk and easily transported. It is possible, however, that some of the fragrant woods mentioned in the Egyptian records as having been received from Punt may have been of Indian origin. From the Eighteenth Dynasty onwards the varnish resins may have come from, or through, India and possibly at a later date indigo and, still later, certainly cotton.

To bring to Egypt most of the foreign materials enumerated Egyptian ships were trading both in the Mediterranean and the Red Sea, the former sailing along the coasts of Palestine and Syria to the port of Byblos, especially to carry the bulky timber from the Lebanons that could not be transported easily otherwise, and the latter down the Gulf of Suez and the Red Sea to the Somali and Arabian coasts; the Sudan and Nubian produce was carried by way of the Nile, which is a great natural highway passing through the country from south to north.

At a very early date the whole country, and particularly the desert, was scoured for useful natural materials, thus during the Old Kingdom, when the capital was at Memphis in the Delta, alabaster was quarried near Helwan; amethyst was brought either from the eastern or western desert; a special diorite was brought from the western desert in Nubia; gold from Nubia; granite from Aswan; malachite and copper from Sinai; natron from the Wadi Natrun; porphyritic rocks from the eastern desert; 'schist' from between Qena and Quseir and turquoise from Sinai.

Intercourse with other countries meant, not only the import of foreign commodities, but also the export of Egyptian commodities to pay for them, since at the time under consideration, coined money was unknown and barter was the only means of exchange. Exactly what these exports were is not known, but among the objects the Egyptians had to offer were faience, glass, gold, jewellery, including precious and semi-precious stones, linen, papyrus and stone vessels.

But more valuable than the material objects exchanged was the knowledge given and received, a subject already touched upon, but any detailed discussion of which is outside the scope of the present book.

APPENDIX

CHEMICAL ANALYSES

Modern Egyptian Gypsum[1]

	%	%	%
Gypsum (hydrated calcium sulphate)	75.4	85.2	89.9
Sand	7.6	3.7	2.1
Calcium carbonate	15.2	9.4	7.5
Oxides of iron and aluminium	1.0	1.0	0.5
Not determined	0.8	0.7	—
	100.0	100.0	100.0

Ancient Egyptian Lime Mortar (Roman Period)[2]

	%	%	%	%
Sand	73.5	22.3	54.9	29.1
Oxides of iron and aluminium	3.7	7.5	13.3	4.0
Lime	10.1	33.9	14.6	34.7
Magnesia	0.7	1.8	3.2	2.1
Sulphur trioxide	1.4	3.2	nil	0.9
Carbon dioxide, combined water, etc.	10.6	31.3	14.0	29.2
	100.0	100.0	100.0	100.0

Ancient Egyptian Lime Mortar (Ptolemaic Period)[3]

	%	%	%	%	%	%	%
Sand	29.0	30.6	38.4	25.4	23.8	27.4	8.8
Oxides of iron and aluminium	3.0	1.8	3.0	2.9	1.7	2.6	1.2
Lime	1.8	26.2	20.2	27.3	25.5	27.3	46.1
Magnesia	—	—	—	—	—	—	—
Carbon dioxide, combined water, etc.	66.2	41.4	38.4	44.4	49.0	42.7	43.9
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1] From Helwan. Analyses by A. Lucas.

[2] Analyses by A. Lucas.

[3] Renato Salmoni, Sulla composizione di alcune antiche malte Egiziane, in *Atti e Memorie della R^a. Accademia di Scienze Lettere ed Arti in Padova, 1933* (XI), Vol. XLIX. The method of presentation has been changed by me.

Ancient Egyptian Gypsum Mortar[1]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Gypsum (hydrated calcium sulphate)	46·9	66·9	73·1	78·0	47·3	54·0	23·4	57·2	54·4	54·4	89·2	70·7	79·6	80·0	97·3	84·0	89·2	78·6	99·5
Sand	12·6	25·5	15·4	12·3	11·5	11·4	4·8	7·4	3·2	7·8	2·0	9·5	6·9	12·8	2·0	8·0	6·0	13·5	tr.
Calcium carbonate	37·1	tr.	6·9	4·3	38·6	32·3	58·0	30·4	39·5	26·6	tr.	8·0	3·5	tr.	—	8·0	4·8	3·7	—
Magnesium carbonate	1·3	0·8	1·6	2·1	tr.	1·3	3·8	3·8	tr.	tr.	tr.	1·3	tr.	tr.	—	—	—	0·8	—
Oxides of iron and aluminium	1·5	2·0	1·8	1·4	1·3	1·0	0·7	1·1	0·6	2·2	0·8	2·6	1·1	1·2	—	tr.	tr.	2·9	—
Not determined...	0·6	4·8	1·2	1·9	1·3	—	9·3	0·1	2·3	9·0	8·0	7·9	8·9	6·0	0·7	—	—	0·5	0·5
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

Nos. 1 to 6. From the sphinx.
Nos. 7 to 9. From the valley temple of Chephren.
Nos. 10 and 11. From the pyramid of Chephren.
Nos. 12 to 15. From the pyramid of Cheops.
Nos. 16 and 17. From the Mastaba el Faraun. IVth Dynasty.
No. 18. From the hypostyle hall, Karnak.
No. 19. From the tomb of Hetepheres. IVth Dynasty.

[1] Analyses by A. Lucas.

Ancient Egyptian Gypsum Plaster[1]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Gypsum (hydrated calcium sulphate)	78·2	76·7	78·1	75·9	83·0	78·1	74·4	84·8	66·3	17·0	75·9	68·5	67·1	36·9	15·5	39·8	40·5	42·7	45·0	83·3	34·6
Sand	10·8	13·0	11·0	11·0	17·0	15·0	15·0	9·0	16·0	10·0	14·0	12·0	11·0	27·0	17·0	15·0	30·0	25·0	36·0	14·0	27·0
Calcium carbonate[2]	11·0	10·3	10·9	13·1	tr.	6·9	10·6	6·2	17·7	73·0	10·1	19·5	21·9	36·1	67·5	45·2	29·5	32·3	19·0	2·7	38·4
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

Nos. 1 to 10. From the tomb of Tut-ankhamun. See A. Lucas, *Appendix* II, pp. 162-3 in *The Tomb of Tut-ankh-Amen*, II, Howard Carter. Some of these specimens are of a grey colour owing to the presence of particles of unburnt fuel.
No. 11. Used as a cement to repair the lid of the sarcophagus in the tomb of Tut-ankhamun. This was the principal cementing material, though there was also another cement in places consisting of a mixture of resin and powdered limestone. See A. Lucas, *op. cit.*, p. 168.
Nos. 12 and 13. From the "Cache of Akhenaten" (XVIIIth Dynasty).
No. 14. From the tomb of Siptah (XIXth Dynasty).
No. 15. From the tomb of Setnakht (No. 14, XXth Dynasty).
Nos. 16 to 19. From the tomb of Seti II (No. 15, XIXth Dynasty).
Nos. 20 and 21. From the tomb of Ramesses XIIth (XXth Dynasty).

[1] Analyses by A. Lucas.
[2] With a small proportion of oxides of iron and aluminium.

ANCIENT EGYPTIAN WHITEWASH[1]

	1 %	2 %
Gypsum (hydrated calcium sulphate)	1.5	9.6
Sand	11.0	32.0
Calcium carbonate, etc.	87.5	58.4
	100.0	100.0

No. 1. From the 'Cache of Akhenaten' (XVIIIth Dynasty).
No. 2. From the tomb of Seti II (No. 15, XIXth Dynasty).

[1] Analyses by A. Lucas.

PLASTER MOULDS FOR BRONZE FIGURES[2]

	1 %	2 %
Gypsum (hydrated calcium sulphate)	97.3	95.8
Silica	1.3	3.4
Calcium carbonate	tr.	tr.
Oxides of iron and aluminium	1.4	0.8
	100.0	100.0

[2] Analyses by A. Lucas. See C. C. Edgar, *Greek Moulds*, p. iii.

ANCIENT EGYPTIAN FAIENCE

Body Material (Ordinary Faience)

	1 %	2 %	3 %	4 %	5 %	6 %	7 %
Silica	94.0	94.2	94.2	99.6	94.7	94.2	90.1
Alumina	1.8	0.6	1.9	0.3	1.4	0.6	1.1
Oxide of iron	0.9	1.6	0.3			1.6	2.7
Lime	2.0	1.7	1.6	0.3	1.7	1.7	2.7
Magnesia	1.1	1.8	0.1	—	1.8	1.8	—
Alkalies	0.3	—	1.1	—	0.4	—	2.7
Not determined	—	0.1	0.8	—	—	0.1	0.7
	100.1	100.0	100.0	100.2	100.0	100.0	100.0

Nos. 1, 2, 3. W. Burton, *Ancient Egyptian Ceramics*, in *Journal Royal Society of Arts*, LX (1912), p. 594.
No. 4. XIXth Dynasty. Analysis by A. Lucas. Specimen of finely divided, white material.
No. 5. XIXth–XXth Dynasty. Analysis by A. Lucas. Specimen of coarse, yellowish-brown material.
No. 6. XXIInd Dynasty, L. Franchet, *Céramique primitive*, p. 41.
No. 7. XIXth Dynasty, W. C. Hayes, *Glazed Tiles from a Palace of Ramesses II at Kantir*, p. 8, *n.* 36.

Glaze (Ordinary Faience)

	1	2
	%	%
Silica	75.6	92.9
Alumina	0.8	0.3
Oxide of iron	0.8	0.5
Lime	3.8	0.8
Magnesia	0.7	—
Oxide of tin	nil	—
Oxide of lead	nil	—
Oxide of copper	1.8	1.1
Potash	10.7	0.5
Soda	5.5	1.6
Oxide of manganese	0.3	—
Not determined	—	2.3
	100.0	100.0

No. 1. Blue colour: Roman date from Dima (Fayum). Analysis by J. Clifford, F.R.I.C., for A. Lucas.

No. 2. Pale greenish blue: XIXth Dynasty. W. C. Hayes, *Glazed Tiles from a Palace of Ramesses II at Kantir*, p. 9, *n.* 38.

	Faience Variant D				*Faience Variant E*
	1	2	3	4	5
	%	%	%	%	%
Silica	94.4	92.3	93.9	95.3	88.6
Alumina	2.4	1.1	1.0	1.6	1.4
Oxide of iron	0.2	0.3	0.1	0.4	0.4
Lime	1.3	0.6	1.7	1.7	2.1
Magnesia	—	—	—	—	—
Alkalies	1.2	2.5	2.4	0.6	5.8
Oxide of copper	0.5	0.8	0.8	0.4	1.7
Oxide of manganese	—	2.4	—	—	—
	100.0	100.0	99.9	100.0	100.0

Nos. 1, 3. Saqqara: Saïte period.

No. 2. Thebes: XXth Dynasty.

No. 4. Saqqara: Ptolemaic period.

Analyses by H. Le Chatelier, *Comptes rendus*, 1889, 129 (12), pp. 477–80; quoted by J. Llorens i. Artigas, *Les pastes ceramiques i els esmalts blaus de l'antic Egipte*, Barcelona, 1922.

No. 5. H. Le Chatelier, *Comptes rendus*, 1899 (7), pp. 387–8; quoted in *Journ. Chem. Industry*, 1899, p. 917.

Ancient Egyptian Glass[1]

	%	%	%	%	%	%	%	%	%	%	%	%	%
Silica	68·3	68·0	59·0	60·7	59·8	59·9	60·3	60·1	58·7	57·9	58·0	60·4	60·1
Oxides of iron and aluminium	3·2	4·0	3·9	2·3	2·7	2·7	2·3	3·1	5·0	5·3	5·0	3·5	3·8
Lime	4·9	5·0	3·7	3·6	3·4	3·9	3·8	3·7	3·8	5·4	5·6	3·8	5·1
Magnesia	1·0	0·9	3·0	3·0	3·0	2·8	2·6	2·0	1·8	1·1	1·0	2·2	1·0
Potash	2·0	2·2	} 30·2	29·8	30·5	30·1	30·4	1·4	} 29·6	29·7	29·9	1·4	} 28·7
Soda	20·2	19·4						29·1				28·3	
Oxide of manganese	0·3	0·3	0·4	0·6	0·5	0·7	0·6	0·4	1·0	0·4	0·4	0·4	1·1
Oxide of cobalt	—	—	—	tr.	tr.	tr.	tr.	tr.	tr.	nil	tr.	—	—
Oxide of copper	—	—	—	—	—	—	—	—	—	tr.	—	tr.	tr.
	99·9	99·8	100·2	100·0	99·9	100·1	100·0	99·8	99·9	99·8	99·9	100·0	99·8
	Trans. XIIth	Yell. XIIth	Or.-yell. XVIIIth	Blue XVIIIth	Blue XVIIIth	Blue XVIIIth	Blue XVIIIth	Blue XXth	Blue XXth	Blue Persian	Blue Persian	Green XXth	? Byzant

[1] H. D. Parodi, *La Verrerie en Égypte*, 1908.

Ancient Arab Glass[1]

Silica	% 67·8	% 68·0	% 66·4	% 67·0	% 55·7	% 56·6	% 68·7	% 66·7	% 68·3	% 67·4	% 68·3	% 67·9	% 68·0	% 68·0	% 63·1	% 64·2	% 58·1
Oxides of iron and aluminium ...	4·0	4·2	5·1	5·0	8·3	8·0	2·2	5·4	3·3	2·7	2·1	2·9	2·6	2·1	0·6	3·0	7·4
Lime	2·9	2·6	4·7	4·2	4·6	4·7	8·6	7·4	8·7	8·1	8·0	8·3	8·1	8·2	3·5	5·0	4·9
Magnesia	0·9	0·9	1·4	1·1	3·3	3·7	4·2	3·5	3·2	4·0	3·7	3·7	4·1	4·2	—	nil	3·0
Potash	23·5	23·4	22·6	21·7	25·1	24·0	2·9	3·9	2·5	2·6	2·5	2·5	2·1	2·7	31·0	26·7	25·3
Soda							12·5	12·4	12·7	14·4	14·7	13·3	14·1	14·0			
Oxide of manganese	0·9	0·8	0·6	0·9	1·9	1·3	0·7	0·7	0·6	0·7	0·8	0·8	0·7	0·8	0·8	0·8	1·1
Oxide of cobalt ...	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxide of copper ...	tr.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oxide of sulphur ...	—	—	—	—	1·0	1·1	—	—	—	—	—	—	—	—	—	—	—
	100·0	99·9	100·8	99·9	99·9	99·4	99·8	100·0	99·3	99·9	100·1	99·4	99·7	100·0	99·0	99·7	99·8
	Blue	—	—	—	Blue	Blue	—	—	—	—	—	—	—	—	—	—	—

[1] H. D. Parodi, *La Verrerie en Égypte*, 1908.

Ancient Egyptian Glass[1]

	1	2	9	13	21	23	24	3	4	5	14	6	15	16	7	8	18	19	20	10	11	22	12	17
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
ica	61·7	59·6	62·6	68·1	66·3	68·5	67·5	50·9	62·7	62·4	60·8	64·1	64·7	60·3	62·3	51·4	58·5	59·1	55·6	63·9	63·2	66·0	65·9	67·3
ide of iron ...	0·7	0·4	0·6	0·7	0·8	0·9	0·1	1·1	1·0	0·8	0·6	0·5	0·8	10·0	0·6	0·8	0·9	1·6	1·3	0·7	0·5	0·3	0·8	0·5
ide of aluminium ...	2·5	3·0	0·8	1·9	3·3	3·9	5·0	2·9	1·5	1·0	2·2	1·3	2·8	2·6	0·8	0·9	5·0	3·6	3·5	0·7	1·0	2·5	1·3	2·6
ne	10·1	10·6	9·3	4·2	7·1	9·9	10·3	10·3	9·2	9·2	1·5	7·0	7·1	6·5	10·1	8·4	10·7	9·8	8·4	7·9	9·1	6·9	9·1	6·8
gnesia... ...	5·1	4·4	4·4	1·3	1·5	1·2	0·8	4·5	4·5	3·1	1·5	3·8	2·1	1·2	4·2	2·5	3·4	3·1	2·7	4·2	5·2	1·4	3·7	1·9
tash	1·6	7·4	2·8	1·9	0·4	0·2	0·1			2·8	—	2·8	—	0·5	—	1·9	7·6	6·4	2·8	0·8	0·4	1·0	0·6	—
da	17·6	14·9	18·2	18·9	19·3	14·8	15·4	19·0	20·3	18·1	29·0	19·3	20·4	18·8	19·9	17·2	9·0	10·3	12·2	22·7	20·6	20·3	18·0	20·4
ide of manganese ...	0·5	tr.	—	—	0·6	0·8	0·5	—	—	—	—	0·3	0·5	0·3	0·9	—	0·5	0·7	0·3	tr.	—	1·0	—	—
ide of copper	0·3	0·5	0·5	2·7	1·0	—	0·3	—	—	2·0	3·0	0·2	0·2	—	—	12·0	2·1	2·5	4·4	—	—	—	—	—
ide of lead	—	—	—	—	—	—	—	—	—	0·5	—	—	1·3	—	—	—	1·3	3·0	6·3	—	—	—	—	—
ide of tin ...	—	—	0·5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·5
lphur trioxide	—	—	0·5	—	—	—	—	2·4	0 9	0·7	0·9	0·8	—	—	1·2	5·5	1·4	0·5	1·8	—	—	1·1	0·8	—
	100·1	100·8	100·2	99·7	100·3	100·2	100·0	91 1	100·1	100·6	99·5	100·1	99·9	100·2	100·0	100·6	100·4	100·6	99·3	100·9	100·0	100·5	100·2	100·0
	Blue							Yellow		Green		Black			Purple	Red				Colourless			Honey White	Milk

Nos. 1 to 12 inclusive are from the XVIIIth Dynasty ; Nos. 13 to 22 inclusive are of the period 2nd to 1st century B.C. ; and Nos. 23 and 24 are Alexandrine.

[1] B. Neumann and G. Kotyga, Antike Gläser, ihre Zusammensetzung und Farbung, in Zeitschrift für angewandte Chemie, 1925, pp. 776-80 ; 857-64.
The numbers are those of Neumann and Kotyga : the specimens have been rearranged according to colour.

ARAB GLASS FROM FOSTAT[1]

	%	%	%	%
Silica	71.2	70.5	66.3	49.4
Phosphoric anhydride	0.3	0.6	0.6	1.2
Oxide of iron	1.4	1.9	4.6	8.6
Oxide of aluminium	1.0	0.8		14.5
Lime	8.1	7.8	10.5	18.7
Magnesia	3.2	1.2	1.0	1.4
Potash	2.1	tr.	3.8	3.5
Soda	11.4	16.1	11.1	2.4
Oxide of manganese	1.2	1.1	2.4	0.3
	99.9	100.0	100.3	100.0
	Blue	Green	Green	Green

[1] Analyses by J. Clifford, F.R.I.C., for A. Lucas.

MODERN EGYPTIAN COPPER ORE

	1 %	2 %	3 %
Copper	3.1	36.3	48.6
Iron	25.8	—	—
Oxide of aluminium	2.4	—	—
Insoluble residue	55.4	—	—
Sulphuric acid	tr.	—	—
Nickel and zinc	nil	—	—
Lead	—	—	—
Sulphur	—	—	—
Not determined	13.3	63.7	51.4
	100.0	100.0	100.0

No. 1. Chrysocolla. From Wadi Samra (Eastern Sinai). Analysis by C. H. Desch. Kindly communicated by G. A. Garfitt, Honorary Secretary, Sumerian Copper Committee.

Nos. 2 and 3. From Wadi Araba (eastern desert). Analyses by Chemical Department, Cairo.

ANCIENT EGYPTIAN COPPER SLAG[1]

	%
Insoluble in acid	37.9
Copper	21.7
Lead[2]	38.0
Iron	1.9
Nickel and cobalt	tr.
Arsenic	0.5
Antimony, silver, bismuth	nil
	100.0

[1] From near Serabit el Khadim in Sinai. Analysis by J. Sebelien, *Early Copper and its Alloys*, in *Ancient Egypt*, 1924, p. 10.

[2] The presence of such a large proportion of lead is very extraordinary and needs explanation.

ANCIENT EGYPTIAN COPPER OBJECTS[1]

No.	Object	Copper	Iron	Zinc	Arsenic	Tin	Silver; Bismuth	Nickel	Lead	Sulphur	Sand	Not determined	Total
		%	%	%	%	%	%	%	%	%	%	%	%
1	Axe	98·0	—	—	—	—	—	—	—	—	—	2·0	100·0
2	Axe	98·1	—	0·3	tr.	—	—	—	—	—	—	1·6	100·0
3	Axe	100·0	tr.	—	—	—	—	—	—	—	—	—	100·0
4	Axe	99·6	—	—	—	—	—	—	—	—	—	0·4	100·0
5	Axe	97·2	—	0·3	—	—	—	tr.	—	—	—	2·5	100·0
6	Axe	99·0	—	—	—	—	tr.	—	—	—	—	1·0	100·0
7	Axe	98·3	—	—	—	—	—	—	—	—	—	1·7	100·0
8	Adze	99·9	tr.	tr.	—	—	tr.	—	—	—	—	0·1	100·0
9	Adze	97·6	—	—	—	—	—	—	—	—	—	2·4	100·0
10	Adze	97·7	tr.	—	—	—	—	—	—	—	—	2·3	100·0
11	Adze	99·6	—	—	—	—	tr.	—	—	—	—	0·4	100·0
12	Adze	97·0	0·5	—	—	—	—	0·4	—	0·3	—	1·8	100·0
13	Adze	94·2	2·5	—	—	—	—	—	—	—	0·4	2·9	100·0
14	Chisel	98·7	—	—	—	—	tr.	—	—	—	—	1·3	100·0
15	Chisel	98·0	tr.	tr.	0·3	—	tr.	—	—	—	—	1·7	100·0
16	Chisel	98·8	0·6	0·2	—	—	tr.	—	—	—	—	0·4	100·0
17	Knife	98·5	—	0·3	0·6	—	—	—	—	—	—	0·6	100·0
18	Bar	98·1	—	—	0·2	—	—	—	—	—	—	1·7	100·0
19	Bar	88·0	0·1	—	—	—	—	—	—	—	8·0	3·9	100·0
20	Chisel	97·7	0·5	tr.	—	—	—	—	—	—	—	1·8	100·0
21	Adze	98·0	tr.	tr.	tr.	—	—	—	tr.	—	—	2·0	100·0
22	Chisel	97·6	1·2	—	—	—	—	—	—	—	1·4	—	100·2
23	Chisel	98·5	tr.	—	—	—	—	—	—	—	0·3	1·2	100·0
24	Adze	58·0	—	—	—	—	—	—	—	—	20·0	22·0	100·0

Nos. 1 to 19 inclusive, Ist Dynasty.
No. 20, IInd Dynasty.
No. 21, VIth Dynasty.
No. 22, XIIth Dynasty.
No. 23. XVIIIth Dynasty.
No. 24, possibly XXth Dynasty.

[1] Analyses by J. Sebelien, *Early Copper and its Alloys*, in *Ancient Egypt*, 1924, p. 8.

ANCIENT EGYPTIAN COPPER OBJECTS

No.	Object	Copper	Iron	Tin	Lead	Nickel Cobalt	Arsenic	Antimony	Bismuth	Sulphur	Manganese	Not determined	Total
		%	%	%	%	%	%	%	%	%	%	%	%
1	Axe	97·4	0·2	tr.	0·2	1·3	0·5	tr.	—	—	0·1	0·3	100·0
1A	Bangles	77·6	0·2	—	0·1	0·1	tr.	—	—	—	—	22·0	100·0
1B	Tool	98·5	tr.	—	tr.	1·2	pres.	—	tr.	—	—	0·3	100·0
2	Dagger	99·5	0·1	nil	tr.	nil	0·4	—	nil	—	—	—	100·0
3	Model Knife	99·6	0·2	0·2	—	—	—	—	—	—	—	—	100·0
4	Chisel	93·2	tr.	tr.	0·1	—	0·1	—	nil	—	—	—	100·0
5	Adze	99·6	tr.	nil	—	—	0·4	tr.	—	tr.	—	—	100·0
6	Adze	99·5	tr.	nil	—	—	0·5	tr.	—	tr.	—	—	100·0
7	Pick	100·0	—	tr.	—	—	pres.	tr.	—	—	—	—	100·0
8	Statue	98·2	0·7	—	—	1·1	—	—	—	tr.	—	—	100·0
9	Model Tool	98·4	0·2	nil	tr.	—	0·3	tr.	tr.	—	—	1·1	100·0
10	Axe	93·3	0·2	0·5	—	—	3·9	0·2	—	—	—	1·9	100·0
11	Strip	95·0	0·3	tr.	0·3	0·1	4·2	—	tr.	—	—	0·1	100·0
12	Axe	88·9	—	0·2	0·6	—	5·6	0·7	—	—	—	4·0	100·0
13	Ingot	93·0	5·9	—	—	—	0·1	—	—	1·0	—	—	100·0
14	Axe	96·9	0·7	0·2	—	tr.	1·5	—	—	tr.	—	0·7	100·0
15	Knife	96·7	1·2	tr.	0·6	0·3	0·8	—	0·4	—	—	—	100·0
16	Knife	97·1	0·4	0·2	—	—	2·3	—	—	—	—	—	100·0

No. 1. Middle Predynastic. Sir H. C. H. Carpenter, *Nature*, 130 (1932), pp. 625–6.

No. 1A. Predynastic. Analyses by C. O. Bannister, *Cemeteries of Armant*, 1, Sir R. Mond and O. H. Myers, pp. 117–20.

No. 1B. Protodynastic. Analyses by C. O. Bannister, *op. cit.*

No. 2. Ist Dynasty. H. Garland and C. O. Bannister, *Ancient Egyptian Metallurgy*, p. 34.

No. 3. IIIrd Dynasty. Analysis by A. Lucas, in *Excavations at Saqqara* (1911–12). *The Tomb of Hesy*, J. E. Quibell, p. 40.

No. 4. Early Dynastic (Nubia). Analysis by C. O. Bannister, in *Report of the British Assen.*, C. H. Desch, 1928, pp. 437–41. Also silver, 2.5 per cent and gold 4.1 per cent.

No. 5, 6, 7. IVth Dynasty. J. H. Gladstone, *Proc. Soc. Bibl. Arch.* XIV (1892), pp. 223–7.

No. 8. Pepy I statue, VIth Dynasty. C. H. Desch, *Report of the Brit. Assen.*, 1928, pp. 437–41.

No. 9. Old Kingdom. Analysis by J. H. Gladstone, in *El Kab*, J. E. Quibell, p. 4.

No. 10. XIIth Dynasty. J. H. Gladstone, *Proc. Bibl. Arch.* XII (1890), pp. 227–34.

No. 11. XIIth Dynasty. H. Garland and C. O. Bannister, *op. cit.*, p. 68.

No. 12. Possibly XIIth Dynasty. G. B. Phillips, in *Ancient Egypt*, 1924, p. 89.

No. 13. Possibly XIIth Dynasty. From Bir Nasb, Sinai, C. H. Desch, *op. cit.*, pp. 437–41.

No. 14. Pan Grave. Sir H. C. H. Carpenter, *Nature*, 127 (1931), pp. 589–91. See also G. Brunton, *Mostagedda*, p. 132.

No. 15. XVIIIth Dynasty. Analysis by W. B. Pollard, in *Journ. Inst. Metals*, H. Garland, x (1913), p. 330.
No. 16. XIXth Dynasty. Analysis by Dr. Percy, in *Proc. Soc. Bibl. Arch.*, J. H. Gladstone, xii (1890), p. 229.

ANCIENT EGYPTIAN BRONZE OBJECTS

No.	Object	Copper	Tin	Lead	Antimony	Arsenic	Nickel	Iron	Zinc	Sulphur	Not determined	Total
		%	%	%	%	%	%	%	%	%	%	%
1	Rod	89·8	9·1	—	tr.	0·5	—	tr.	—	tr.	0·6	100·0
2	Vase	86·2	5·7	nil	—	nil	—	nil	nil	—	8·1	100·0
3	Bowl	85·8	3·5	8·5	—	—	—	0·2	—	—	2·0	100·0
4	Axe	85·9	12·1	0·8	—	—	—	—	—	—	1·2	100·0
5	Chisel	93·6	7·4	—	tr.	0·5	—	—	—	—	—	101·5
6	Bracelet	68·4	16·3	nil	—	nil	—	tr.	tr.	—	15·3	100·0
7	Hook	69·2	9·8	—	—	nil	—	—	—	—	21·0	100·0
8	Chisel	96·4	2·2	—	—	0·4	—	—	—	—	1·0	100·0
9	Figurine	91·9	6·3	—	—	—	—	—	—	—	1·8	100·0
10	Figurine	88·4	11·9	—	—	—	—	—	—	—	—	100·3
11	Adze	89·8	3·1	—	tr.	0·3	—	—	0·4	—	6·4	100·0
12	Chisel	88·0	12·0	0·1	tr.	0·4	—	—	0·3	—	—	100·8
13	Axe	89·6	6·7	—	tr.	1·0	—	0·5	—	—	2·2	100·0
14	Axe	90·1	7·3	—	tr.	0·2	—	—	—	tr.	2·4	100·0
15	Adze	67·6	9·6	—	—	—	0·6	tr.	—	—	22·2	100·0

No. 1. IVth Dynasty. J. H. Gladstone, *Proc. Soc. Bibl. Arch.* xiv (1892), pp. 223–7.
No. 2. VIth Dynasty. M. Berthelot, in *Fouilles à Dahchour*, 1894, J. de Morgan, pp. 136–45.
No. 3. Possibly XIth Dynasty. G. B. Phillips, in *Ancient Egypt*, 1924, p. 89.
Nos. 4, 5. XIIth Dynasty. J. Sebelien, *Ancient Egypt*, 1924, p. 8.
Nos. 6, 7. XIIth Dynasty. M. Berthelot, *op. cit.*, pp. 136–45.
No. 8. XIIth Dynasty. J. H. Gladstone, *Proc. Soc. Bibl. Arch.*, xii (1890), pp. 227–34.
No. 9. IXth or XIth Dynasty. H. R. Hall, *Some Early Copper and Bronze Egyptian Figurines*, in *Annals of Arch. and Anthrop., Liverpool*, xvi (1929), pp. 14, 15.
No. 10. IXth or XIth Dynasty. H. R. Hall, *op. cit.*
Nos. 11, 12. XVIIIth Dynasty. J. Sebelien, *op. cit.*, p. 8.
Nos. 13, 14. XVIIIth Dynasty. J. H. Gladstone, *Proc. Soc. Bibl. Arch.*, xii (1890), pp. 227–34.
No. 15. XIXth Dynasty. J. Sebelien, *op. cit.*, p. 8.

ANCIENT EGYPTIAN GOLD OBJECTS

	1	2	3	4	5	6	7	8	9	10
	%	%	%	%	%	%	%	%	%	%
Gold	79·7	84·2	84·0	79·5	91·0	78·0	81·7	80·8	92·3	92·2
Silver	13·4	13·5	13·0	16·8	9·0	18·0	16·1	14·7	3·2	3·9
Copper	nil	nil	nil	2·8	trace	—	trace	4·1	nil	nil
Not determined ...	6·9	2·3	3·0	0·9	—	4·0	2·2	0·4	4·5	3·9
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

	11	12	13	14	15	16	17	18	19	20
	%	%	%	%	%	%	%	%	%	%
Gold	90·5	92·7	90·0	82·9	85·9	96·4	82·3	72·1	89·5	99·8
Silver	4·5	4·9	—	16·6	13·8	1·9	14·3	17·2	11·2	—
Copper	nil	—	—	0·5	0·3	pres.	1·5	13·1	nil	—
Not determined ...	5·0	2·4	10·0	—	—	1·7	1·9	—	—	0·2
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	102·4	100·7	100·0

Nos. 1, 2, 3. 1st Dynasty. Analyses by J. H. Gladstone, in *The Royal Tombs*, W. M. F. Petrie, II, p. 40.

Nos. 4, 5. IIIrd Dynasty. Analyses by Dr. H. E. Cox, F.R.I.C., for A. Lucas, C. M. Firth and J. E. Quibell, *The Step Pyramid*, pp. 140–1. In No. 5 the silver is estimated by difference, Cox giving 11.0 per cent.

Nos. 6, 7. VIth Dynasty. Analyses by J. H. Gladstone, in *Dendereh*, W. M. F. Petrie, pp. 61–2.

No. 8. VII–VIIIth Dynasty. Part of bracelet from Matmar. Analysis by Sir H. C. Carpenter. Kindly communicated by the finder, Mr. Guy Brunton.

Nos. 9, 10. XIth Dynasty. Nos. 11, 12, 13: XIIth Dynasty. No. 20. Persian period. Analyses by M. Berthelot, *Sur l'or égyptien*, in *Annales du Service*, II (1901), pp. 157–63.

Nos. 14, 15. XIIth Dynasty. Analyses by M. Berthelot, *Étude sur les métaux* in *Fouilles à Dahchour*, J. de Morgan, pp. 145–6.

Nos. 16, 17, 18, 19. XVIIIth Dynasty. Analyses by W. B. Pollard, in *The Tomb of Yuaa and Thuiu*, J. E. Quibell, pp. 78–9.

ANCIENT EGYPTIAN ELECTRUM OBJECTS

	1	2	3	4	5	6	7
	%	%	%	%	%	%	%
Gold	80·1	78·7	77·3	78·2	72·9	67·0	71·0
Silver...	20·3	20·9	22·3	21·1	20·5	25·0	29·0
Copper	—	—	—	—	pres.	8·0	—
Not determined ...	—	0·4	0·4	0·7	6·6	—	—
	100·4	100·0	100·0	100·0	100·0	100·0	100·0

Nos. 1, 2, 3, 4. XI–XIIth Dynasty. Analyses by M. Berthelot, *Sur l'or égyptien* in *Annales du Service*, II (1901), pp. 157–63.

No. 5. XVIIIth Dynasty. Analysis by W. B. Pollard, in *The Tomb of Yuaa and Thuiu*, J. E. Quibell, pp. 78–9.

No. 6. XVIIIth Dynasty. Analysis by Alex. Scott in *The Tomb of Tut-ankh-Amen*, Howard Carter, II, p. 211.

No. 7. XVIII–XIXth Dynasty. C. R. Williams, *Gold and Silver Jewelry and Related Objects*, p. 118.

ANCIENT EGYPTIAN SILVER OBJECTS

	1	2	3	4	5	6
	%	%	%	%	%	%
Gold	38·1	8·9	14·9	pres.	1·0	8·7
Silver	60·4	90·1	74·5	69·2	61·0	82·5
Copper	1·5	1·0	—	pres.	0·6	8·9
Lead	—	nil	—	nil	nil	—
Not determined	—	—	10·6	30·8	37·4[1]	—
	100·0	100·0	100·0	100·0	100·0	100·1

	7	8	9	10	11	12
	%	%	%	%	%	%
Gold	8·4	5·1	2·7	3·2	17·9	1·2
Silver	84·9	90·2	92·1	92·5	82·1	94·8
Copper	4·3	4·5	3·3	3·9	tr.	1·7
Lead	—	0·2	tr.	0·5	—	0·2
Not determined	2·4	—	1·9	—	—	2·1
	100·0	100·0	100·0	100·0	100·0	100·0

No. 1. Early Dynastic. Analysis by C. Friedel, in *Les nouvelles fouilles d'Abydos*, 1895–96, E. Amélineau, p. 274.

[1] Chiefly silver chloride.

No. 2. IIIrd Dynasty. Analysis by H. E. Cox, F.R.I.C., for A. Lucas. From the tomb of Hetepheres at Giza, discovered by G. A. Reisner.
No. 3. XI–XIIth Dynasty. Analysis by M. Berthelot, in *Annales du Service*, II (1901), pp. 157–63.
No. 4. XIIth Dynasty. Analysis by M. Berthelot, in *Fouilles à Dahchour*, J. de Morgan, pp. 145–6.
No. 5. Pan-grave. Analysis by H. E. Cox, F.R.I.C., for A. Lucas. See G. Brunton, *Mostagedda*, p. 132.
Nos. 6, 7. XVIIIth Dynasty. Analyses by W. B. Pollard, in *The Tomb of Yuaa and Thuiu*, J. E. Quibell, pp. 78–9.
No. 8. XVIIIth Dynasty. Analysis by Alex. Scott, in *The Tomb of Tut-ankh-Amen*, Howard Carter, p. 210.
No. 9. XVIIIth Dynasty. Analysis by H. E. Cox, F.R.I.C., for A. Lucas. Found by Pendlebury at El-Amarna. H. Frankfort and J. D. S. Pendlebury, *The City of Akhenaten*, II, p. 60.
No. 10. XIXth Dynasty. C. R. Williams, *Gold and Silver Jewelry and Related Objects*, p. 29.
No. 11. 4th–5th century B.C. C. R. Williams, *op. cit.*, p. 143.
No. 12. Early A.D. Analysis by H. E. Cox, F.R.I.C., for A. Lucas. Found by W. B. Emery at Qustul in Nubia.

Two other specimens of silver examined spectrographically gave the following results:

	A	*B*
Gold	A few per cent.	5–10 per cent.
Copper	A few per cent.	A few per cent.
Lead	Less than 1 per cent.	Less than 1 per cent.
Tin	Trace	Trace
Nickel	Slight trace.	——

A. XIIth Dynasty. From Tôd. Analysis by Dr. H. Kenneth Whalley, Gov. Lab., London, for A. Lucas. See ref. No. 5, p. 280.
B. XXIInd Dynasty. From coffin of Sheshanq, Tanis. Analysis by Dr. H. Kenneth Whalley for A. Lucas. See ref. No. 1, p. 280.

MODERN NATRON FROM THE WADI NATRUN[1]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Sodium carbonate[2] ...	38·2	22·4	28·9	35·5	43·5	28·9	58·6	75·0	67·8	33·4	38·3	41·8	35·4	53·9
Sodium bicarbonate[2]...	32·4	6·2	20·5	25·8	33·8	9·9	14·3	5·0	8·6	25·2	18·3	29·4	12·1	24·2
Sodium chloride ...	6·7	26·4	24·8	14·0	4·8	26·8	7·4	9·4	4·3	20·8	2·2	11·9	12·4	1·9
Sodium sulphate ...	2·3	39·3	5·8	3·0	3·3	27·4	1·3	1·2	0·8	6·1	tr.	3·4	29·9	tr.
Water, free and combined	16·5	5·6	12·8	13·1	13·1	6·9	4·3	3·7	1·9	11·6	10·1	11·2	10·2	20·0
Matter insoluble in water	3·9	0·1	7·2	8·6	1·5	0·1	14·1	5·7	16·6	2·9	31·1	2·3	tr.	tr.
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

[1]Analyses by A. Lucas.

[2]The sodium carbonate and bicarbonate, together with any combined water, constitute the natron proper, the other ingredients being impurities.

MODERN NATRON FROM EL KAB[1]

	%	%	%
Sodium carbonate[2]	13.6	13.3	11.0
Sodium bicarbonate[2]	9.5	2.0	1.5
Sodium chloride	54.6	12.3	57.3
Sodium sulphate	11.4	70.2	29.4
Water, free and combined	4.7	tr.	0.4
Matter insoluble in water	6.2	2.2	0.4
	100.0	100.0	100.0

[1] Analyses by A. Lucas.

[2] The sodium carbonate and bicarbonate, together with any combined water, constitute the natron proper, the other ingredients being impurities.

ANCIENT NATRON FROM TOMBS

	1	2	3	4	5	6	7	8
	%	%	%	%	%	%	%	%
Sodium carbonate[1]	16.1	10.7	9.2	36.9	94.0	35.7	84.7	73.8
Sodium bicarbonate[1]	10.7	11.9	6.3	8.3				
Sodium chloride	25.2	18.2	39.3	9.9	0.5	39.5	1.5	13.0
Sodium sulphate	27.8	12.4	13.2	33.9	5.5	24.8	13.8	13.2
Water, free and combined	8.7	19.8	6.8	5.6	—	—	—	—
Matter insoluble in water	11.5[2]	27.0[3]	25.2	5.4[2]	—	—	—	—
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Nos. 1 and 2. From the tomb of Yuya and Thuyu (XVIIIth Dynasty). See J. E. Quibell, *The Tomb of Yuaa and Thuiu*, pp. vi, 75–7. Analyses by A. Lucas.

No. 3. Found in a vase at Thebes (XVIIIth Dynasty). Analysis by A. Lucas.

No. 4. From near the tomb of Ipy at Deir el Bahari (XIth Dynasty). See H. E. Winlock, *The Egyptian Expedition* 1921–1922, in *Bull. Met. Mus. of Art, New York*, II, 1922, p. 34. Analysis by A. Lucas.

Nos. 5 to 8. From the tomb of Tut-ankhamun. See A. Lucas, *Appendix II*, pp. 178–9, in *The Tomb of Tut-ankh-Amen*, III, Howard Carter. Analyses by H. E. Cox, F.R.I.C., for A. Lucas.

[1] The sodium carbonate and bicarbonate, together with any combined water, constitute the natron proper, the other ingredients being impurities.

[2] Chiefly sand.

[3] A mixture of sand and sawdust.

EGYPTIAN BLUE FRIT

	1 %	2 %	3 %
Moisture	1.6	—	—
Silica	57.2	63.4	70.0
Copper oxide	18.5	19.5	18.3
Oxides of iron and aluminium	0.8	—	0.3
Lime	13.8	14.4	9.4
Magnesia	0.5	—	—
Potash	nil.	1.2	2.0
Soda	7.6	0.9	
	100.0	99.4	100.0

No. 1. XIXth Dynasty. Analysis by A. Lucas.

No. 2. Specimen prepared by Laurie, McLintock and Miles in imitation of the Egyptian material. *Egyptian Blue*, in *Proc. Royal Soc. A.*, 89 (1914), pp. 418–29.

No. 3. J. K. Crow, *Report on Samples of Colours scraped from the Monuments*, in *Annales du Service*, IV (1903), pp. 242–3.

POTTERY CLAY FROM BALLAS[1]

	%
Silica	34.8
Oxide of aluminium[2]	20.6
Oxide of iron[3]	6.1
Oxide of phosphorus	1.1
Lime	12.7
Magnesia	0.4
Potash	1.0
Soda	1.3
Sodium chloride	1.0
Carbon dioxide	8.7
Sulphur trioxide	tr.
Water	12.7
	100.4

[1] Analysis for A. Lucas.

[2] Containing a very small proportion of oxide of titanium.

[3] The iron was all in the ferric condition.

GLAZE FROM ISLAMIC WARE[1]

	1 %	2 %
Silica	47.5	74.0
Alumina	1.0	1.5
Oxide of iron	2.1	2.6
Lime	6.1	2.4
Magnesia	0.7	0.8
Potash	tr.	2.7
Soda	6.2	14.1
Oxide of tin	4.8	0.3
Oxide of lead	31.4	1.4
Oxide of manganese	0.2	0.2
	100.0	100.0

[1] From Fostat. Colours not noted. Analyses by J. Clifford, F.R.I.C., for A. Lucas.

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