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The Journal
Hyderabad Geological Survey

Vol. IV, Part I.

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GENERAL REPORT FOR THE YEARS 1344 AND 1345 FASLI.

By

KHURSHID MIRZA, B.SC. (Durham), C.E., M.I.M.E., M.N.G.I.,
Director of Mines and Geological Survey

The reports embodied in this Journal, Hyderabad Geological Survey, Vol. IV, Part 1, consist of the regular geological survey work of the Department during the field seasons of 1344 and 1345 Fasli (1934-36 A.D.).

It was decided that the work of the Department should be regularly published at stages when sufficient material in the field was collected and the work of the officers co-ordinated to avoid repetition. The journals are intended to be published in volumes of two parts, Part 1, for regular surveys and Part 2, for special and miscellaneous subjects.

Consequent on the sudden death of Capt. L. Munn, O.B.E., Special Officer in charge Geological Survey and Well Sinking Department on 15-1-1345 Fasli, this Department was transferred under me on 2nd Dai 1345 F. and the headquarters of the Department was shifted from Lingsugur to Hyderabad early in the year. During Capt. Munn's administration the work was concentrated on the survey of the Raichur Doab and Gulbarga District with special reference to the gold-bearing Dharwars and also for giving geological advice in connection with Well Sinking operations extensively conducted in the area. After Capt. Munn's demise his plan to complete the survey of the Gulbarga area was also continued.

Work done in 1344 Fasli.

Water-level Survey.

The special feature of the work done during the year 1344 Fasli (1934-35 A.D.) was the study of underground water conditions in parts of Osmanabad, Gulbarga and Mahbubnagar Districts. A summer water-level survey of the Raichur Doab was conducted just before the break-up of the monsoon in May and June and a total length of about 315 miles of the country was traversed. With a view to laying out the work of the Well Sinking operations detailed notes on the rural water-supply entailed the examination of more than 2,000 wells in the areas traversed.

Geological Survey.

The general geological survey was also simultaneously conducted in parts of Surapur, Shahpur and Yadgiri taluqs in Gulbarga District and Makhtal taluq in the Mahbubnagar District, Parenda and parts of Kallam in Osmanabad District and southern portion of Ashti taluq in Bhir District, in all covering about 1,850 sq. miles of the country. Specific bands and patches of Dharwar rocks were located and their boundaries demarcated in Shahpur and Makhtal taluqs.

Besides these, a study of the sequence of the trap flows in the Osmanabad District from 1,500′ to 2,600′ M.S.L. was also made. It is well known that the trap flows consist of hard basaltic trap intercalated with softer vesicular traps which are susceptible to greater decomposition. It has been found by the study of the natural sections and well logs that these specific softer layers in certain horizons are aquiferous and wells driven to these depths have proved of successful perennial supply. Though any correlation in a particular area may not be so uniform or wide-spread as to make it of an universal application, yet, the knowledge gained has proved of immense value within the area limited by the study. The results of enquiry on the water-level relations in the trap-flows have been incorporated in Journal, Hyderabad Geological Survey, Vol. III, Part 2.

Work done in 1345 *Fasli.*

The following areas were surveyed during the year 1345. Fasli.

(i) *Gulbarga District.*

(1) Parts of Surapur and Shahpur taluqs lying between Lat. 16° 30′ and 16° 48′ and Long. 76° and 76° 50′, covering about 466 sq. miles.

(2) Southern parts of Surapur taluq defined by Lat. 16° 30′ on the north, to the State limit on the west and by the Kistna on the south, covering an area of 430 sq. miles.

(3) Parts of Yadgiri taluq bounded on the south by Lat. 16° 35′, on the east by Long. 77° 30′, on the north by Lat. 17° 00′, on the west by the Bhima river, covering an area of about 861 sq. miles.

(ii) *Mahbubnagar District.*

Parts of the Makhtal and Mahbubnagar taluqs and portion of Amarchinta Samasthan defined by Lat. 16° 30′ and 16° 50′ and Long. 77° 30′ and 78° covering about 651 sq. miles.

Geology.

(i) *Gulbarga District.*

Dharwars.

The east and south of the area surveyed in the Gulbarga District consists of the Peninsular Gneissic Complex in which a broad band of Dharwar schists about 16 miles long locally known as Manglur Band has been mapped with a few minor patches of Dharwar schists. A number of dolerite dykes also traverse the country. Many old workings for gold are noted in the Manglur Band of Dharwars where prospecting companies have subsequently worked. Old gold and copper workings near Tathni in the Dharwar formations and indications of copper in the quartz hill near Hebal Buzurg are reported to be of economic interest.

Peninsular Gneisses.

The Peninsular Gneissic rocks occupy the major parts of the country. The grey granites are mostly prominent, generally coarse to medium grained in texture, and make excellent building material. The pink granites and the red syenites afford stones of decorative value in various tints. Some red syenites, have partly altered into well-defined beds of calcium carbonate which appear to be suitable for lime industry.

Bhima Series.

The Bhima Series of the sedimentaries mainly consisting of conglomerates, sandstones, shales and limestones, occur to the north and west of the area and are in places overlain by the Deccan Trap. The limestones occur in various shades of colour which split into flags and constitute an attractive material for flooring and building purposes. The shales and limestones are of quality suited to cement industry. A variety of blue coloured limestone is quarried near Allur and exported to Bombay.

Springs and water falls.

Some springs in the limestone area near Wajal and Chennur and waterfalls near Chennur and south of Gurmatkal on a perennial *nullah* with a head of about 80 ft., deserve notice under irrigation and power scheme.

Deccan Trap.

The Deccan Trap rocks are noted mostly as minor outliers. Some ochre beds occur at the junction of the Deccan Traps and the shale beds near Kolihal may prove of economic value.

Inter-trappean beds.

A well-defined bed of inter-trappean is noted with fossiliferous marls and cherts west of Kanagadda in the Gurmatkal plateau, Yadgir taluq.

(ii). *Mahbubnagar District.*

The geology of the Mahbubnagar area has not received notice by previous observers. The area now surveyed

consists mostly of the Peninsular Gneissic Complex with very subordinate bands and patches of Dharwar schists. The country is traversed by a network of dykes and numerous quartz reefs.

State Salt Enquiry.

The funds required for conducting the experiments were supplied by the Commerce and Industries Department, the amount being provided by the Trustees of the Industrial Trust Fund. A special report on "The Test Bore-holes for the investigation of brine along the Sarjapur Nullah, Raichur District" was prepared in connection with State Salt Enquiry and published in Journal Hyderabad Geological Survey, Vol. III, Part 2.

Salt Industry.

In continuation of the previous programme of work many active and abandoned salt works were located in all the areas surveyed widely distributed along prominent saliferous zones. As sodium sulphate and sodium carbonate were found to be extensive as efflorescences in some of the *nullahs* in Yadgiri and Makhtal taluqs, attention was drawn to their utilisation in glass and ceramic industry. Quartz and feldspars also occur in the neighbourhood. Abandoned Soda works in these areas still testify to the indigenous glass (bangle) industry within the living memory of the villagers.

Building and Decorative Stones.

Based on the representation of this Department to give a trial to the decorative building stones abundantly found in the various localities of the Raichur District and Surapur taluq, a collection of building and decorative stones were sent to the Superintending Engineer, Osmania University Building Project, Hyderabad, for testing their suitability.

Indian Science Congress.

The Department was given an opportunity to participate in the Indian Science Congress Session held in Calcutta during the first week of January 1935 (1345 F.).

The following papers were read from the Department :

(1) [1]Observations and notes on the method of Ancient gold mining with special reference to the Raichur and Shorapur Districts, Hyderabad State.

(2) [2]Prehistoric and Protohistoric find, of the Raichur and Gulbarga Districts.

(3) A Sword Dance and Skewer-piercing ceremony at Tintinni, Shorapur taluq, Hyderabad State.

(4) Some local phase of regional metamorphism of Dharwars in the eastern portion of the Raichur Doab.

(5) Petrological notes on some of the rock types of Kalmali, Kallur, Nilagal and Ganekal hills, Raichur District.

(6) Porphyritic dykes in parts of Raichur and Manvi taluqs.

(7) A note on the bore-hole logs in parts of Aurangabad and Parbhani Districts discussed in relation to the distribution of underground water in Deccan Trap.

Laboratory and Petrological Work.

A large number of brine samples from the eastern portion of the Raichur Doab were completely analysed. Besides this the usual mineral and ore analyses were conducted. As usual, samples of water were analysed for the Well Sinking Department. The Laboratory was in constant use for the quantitative analyses of limestones and other field collections. Qualitative examination of specimens collected either by the Department or sent from outside were also attended to. Microsections of the specimens were made in the Laboratory and the determination of the physical characters of over 70 samples of building stones was undertaken.

1. Transactions of the Mining and Geological Institute of India, Vol. XXX, pp. 103-116

2. Man in India, Vol. XV, 1935, No. 4, pp. 225-250

Drawing Branch.

The Drawing Branch was kept fully occupied. The following work was done :—

(*i*) *Drawing Section.*

1. Transferring and colouring formations from field Topo-sheets received from officers.....14

2. Reducing Topo-sheets from 1″=2 miles scale to 1″=4 miles scale maps.....4

3. Preparation of large-scale maps of geological details (scale 1″=16 miles)..... 2

4. Preparation for the Journal Hyderabad Geological Survery, Vol. III, Part 1. :

Plates	10
Tracings	7
Diagrams and line-blocks ..	5
General sketches, drawings and diagrams	29

(*ii*) *Photographic section* :

Copying, developing, enlarging and printing work for publications and reports.

Plates ½ size exposed	..22
„ ¼ „	.. 6
Prints ½ size taken	..21
„ ¼ „	..10

Besides above, 6 lantern slides were made and 18 microphotos also taken.

Library.

There was an addition of twenty-one books of geological interest in 1344-45 Fasli. Fifty-seven back numbers of Nature were purchased. The Journal of Economic Geology was added to the list of subscribed Journals of the Department and 180 publications were obtained in exchange.

Publications.

Journal, Vol. III, Part 1, of the Hyderabad Geological Survey came out of the press and the copies were distributed to the various institutions in the exchange list.

II. GEOLOGY OF PARTS OF SURAPUR AND SHAHPUR TALUQS, GULBARGA DISTRICT.

By

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Introduction.

In pursuance of the general scheme of work of the Geological Survey Department, after the completion of the survey of the Raichur Doab, attention was directed to the areas north of the Kistna River.

The following report is the work of two seasons, 1344 F., and 1345 F. (A.D. 1934-35 and 1935-36) during which period the southern portions of the Gulbarga District north of the Kistna river was surveyed.

Area. The area under report is included within Lat. 16° 30′-16° 45′ and bounded by the State limits on the west and by the Bhima river on the east, comprising an area of about 900 square miles of the Surapur and Shahpur taluqs of the Gulbarga District, covered by the Survey of India sheets Nos. 56H./SW., 56H./NW., 56D./NE., 56D./NW., scale 2 miles = 1 inch.

An area of 434 sq. miles was mapped during 1344 F. season and the remaining portion up to the State limits in the west, during 1345 F. season.

Object. The main object of continuing the geological survey immediately north of Kistna was to locate and demarcate all extensions of the Dharwar bands of the Raichur Doab north of the Kistna river. The auriferous nature of the Manglur Land has long been known and was confirmed by the activities of gold prospecting companies. One of the objects of the present survey was to investigate the possibilities of reviving gold mining in this area.

Previous notice.

The area under report had already received attention by R. Bruce Foote of the Geological Survey of India who surveyed a part of the Maharatta Country, the geological features of which have been noted in Mem. Geological Survey India Vol. XII, as early as 1875. The present work is mostly of the nature of a revision survey.

Topography.

The area consists of a rudely triangular tract of country lying to the north of the Kistna and to the west of the Bhima River, and constitutes a part of the Bhima basin.

Broadly, this area may be divided into three topographic regions, via (1) Eastern, (2) Central and (3) Western zones.

(1) Eastern zone.

The undulating country of the eastern zone is marked by a few knobs of gneissic hills. The country as a whole, passes to extensive plains towards the Kistna and the Bhima having an average elevation of about 1,100 ft. and lying to the east and south-east of Shahpur and east of Surapur, the taluq headquarters of the area.

(2) Central zone.

The central hilly tracts are mostly diversified by a number of gneissic ridges. The greater part of this high ground lies above the 1,600 ft. contour and has subdued reliefs here and there above the 1,500 ft. contour. This constitutes a longitudinally dissected plateau stretching from north-west near Nagnur to south-east to the neighbourhood of Surapur attaining higher elevations of about 1,800 ft. South of Surapur the grounds drop somewhat steeply into the valley of the Kistna. The marginal hills of this central belt include the ridges to the north-west of Bilaspur on the Surapur-Yadgir road, rising to above 1,800 ft. The hills to the south and west of Shahpur form a minor plateau, which attains to an elevation of about 1,900 ft. On this *massif* of granite gneiss, near Shahpur, the ruins of a strong

hill fort, made by the Adil Shahi Kings of Bijapur, may still be seen at a height of about 520 ft., above the level of the surrounding plain.

The north-west and south-easterly alignment of the hills of this central belt suggests an important orographic feature. Its significance as regards structure in relation to the Dharwars, and the geological history in relation to the Bhima basin, will be noted later on.

Surapur plateau.

The town of Surapur is situated on a picturesque group of ridges forming a minor plateau, about 500 ft. above the level of the southern plains of the Kistna basin broken up into numerous gullies and denudation valleys. In the town area, the valleys are occasionally dammed up to collect rain water; and wells sunk along such valleys feed garden cultivation to supply the town and the neighbouring villages.

Looking to the west, the hills of the Surapur plateau command a wide view of the western plains of Baichbal, thickly cultivated with jawari, pulses and cotton of the winter season. The foot-hills are particularly rugged, with villages few and far between. On their shelving spurs are seen ruined ramparts of ancient forts. The forts of Surapur, Wagangiri and Malbhal and other old watch-towers still recall the memory of the dark days of struggle and strife.

Lake Amapur.

About six miles west of the town of Surapur, west of Amapur, at the foot of the Surapur group of hills, is situated a lake, between the margin of the gneissic plateau to the east and the rolling belt of Dharwars to its west. The dilapidated bungalow of Col. Meadows Taylor is still seen standing on a Dharwar ridge at the western brink of the lake, north of Bonal. This lake, nestled in the weird hills often dissected into knobby ridges, occupies about three square miles, a feature

which breaks the monotony of the dry wildness of a considerable area around.

(3) Western zone

The western portion of the area under report is marked by the Baichbal valley, comprising the western parts of the Surapur taluq. This valley, thickly covered with black cotton soil and intersected by ephemeral streams, is eroded down sometimes below the level of 1,400 ft., at its south-easterly end near Baichbal

Drainage system.

As indicated before, the most important rivers of the area are the Kistna and the Bhima besides a large number of tributaries, which tend towards two main directions ;

(*a*) Those draining into the Bhima ;

(*b*) Those taking their rise on the escarpment or on the slope of the gneissic ridges of the central belt drairing to the Kistna ;

All the drainage to the east eventually reaches the Bhima, which drains a large catchment area to the east. Most of the tributaries are ephemeral, owing to the rainfall being confined to some three months of the year. The average rainfall of the area is between 25 to 30 inches per year. The Bhima in the main is carrying water from a region with an average of over 25 inches of rain through a semi-arid tract in the higher reaches of the Deccan Plateau in the Bombay Presidency.

The river Kistna, entering the southern reaches of the area near Kellur, receives many tributaries and is joined by the Bhima at Sangum. Sharp meandering bends characterise the course of the Kistna south of Gudur, Gondiannur and Chennur, deviating from its normal easterly and south-easterly course.

General Geological Formations.

The major portion of the area is covered towards the east and south by the Peninsular Gneissic Complex associat-

ed with subordinate strips, bands and patches of Dharwar schists. The western and northern portions of the country are represented by the Bhima sedimentaries, consisting of conglomerates, sandstones, shales and limestones. These are finally overlain by the Deccan Trap towards the outer border.

A few dykes and quartz veins traverse the area and on the south-eastern and eastern portions, specially along the northern and western basin of the Kistna and Bhima, respectively, spreads of gravel beds are met with in isolated patches.

The rocks of the area may be divided in ascending order as follows :—

Rock systems.

Soils and alluvium.
Pebble beds.
Deccan Trap.
Bhima Series.
Dykes
Peninsular Complex.
Dharwars.

Dharwars.

Numerous patches of Dharwar schist occur in the area, which may be grouped along two zones in a N.N.W. direction and conveniently described as (1) the Kellur-Gugi patches and (2) the Manglur band of Dharwars.

The Kellur-Gugi patches of Dharwars consist of schists outcropping on the Kistna near Kellur, and run with intervals via Sardhalli, north of Sagar, and extend up to Gugi. These schists are presumably a continuation of the prominent schist band traced as a continuous belt, for a distance of over 30 miles in the Raichur Doab. But here in Shahpur taluq, the band has been broken up and only the remnant patches occur. They are practically free from auriferous blue quartz veins and as such are economically unimportant.

The Manglur band of Dharwars occurs towards the western flank of the central gneissic belt with its associated outlying patches. This band is known to be auriferous.

(1) *Kellur-Gugi Patches of Dharwars.*

An interesting fact is the recognition of the continuation in the schist belt, in the northern bank of the Kistna, of the Raichur band of schists previously described ;* but the exposures on this side of the river are few. Many outlying patches are largely obscured by soil and pegmatites.

(*a*) *Kellur patch.*—The northern continuation of the Raichur band was not seen either in the bed of the Kistna or on the northern bank of the river, but was identifiable about half a mile to the north of the river. Along its northern margin the schist strikes towards N. 35° W., whereas only a N. 22° W. trend, the belt being about its eastern limit has 2 to 3 furlongs in width.

Its northern extension is well seen on the cart-track between Kellur and Tonnur. A furlong to the north of this cart-track, however, the schists are cut away by pegmatites. Here the schists are entirely lost sight of excepting for a few shreds or intercalcations in the natural cuttings or well sections.

(*b*) *Schist patch south-west of Kellur.*—An outcrop of jasperoid siliceous schist occurs on the right bank of the Kistna about two miles south-west of Kellur. Here the schist is veined with quartzites and associated pink pegmatites. Micaceous gneisses are prominently developed, showing exfoliating weathering. The central portion of the band shows hornblende porphyry and epidioritic phases of hornblende

schists. The northern limit of this belt is, however, obscured by black cotton soil, and pegmatites. In some places assimilated schists in the form of veins and intercalcated masses in the gneissic rocks still testify to their original extent.

(c) *Marmakal patch.*—As in the Kellur exposures, the Marmakal patches of schists run along the usual strike of the schists, the constituent rocks being mainly siliceous schists with which porphyroblastic types as well as the epidioritic phases occur. Quartzite has also been noted in the Kistna. At the contact of the schist patches there occur micaceous gneisses, white quartzose gneisses and a series of coarse pink and white pegmatites. These pegmatites are particularly interesting as showing *lit-par-lit* injection in the schists, which occur more or less in the form of lenses and interlocked bands of minor magnitude. Occasionally binary white pegmatites also occur in association. A black coating on the pegmatites often gives, from a distance, a misleading suggestion of their being hornblende schists. The black encrustation is however due to haematitic and manganiferous material. The strike disposition of the pegmatites is usually N N W., varying from N. 10° to 35° W.

Towards the northern end of the belt, the schists are greatly intermingled with pegmatites and assume a pinkish green colour, and probably disappear.

The country north and north-west and east of Marmakal is entirely covered with black cotton soil and no continuation of the hornblende schists could be traced except for a few patches.

(*i*) A few outcrops of epidioritic rocks are observed to the south-west of Hanchnal about 8 miles north-east of Kellur.

(*ii*) On the track between Yawar Wadgira to Hyal Khurd pegmatites occur freely under the black cotton soil and patches of hornblende schists are noted in the road cutting.

(*iii*) On the Ikur track to the south of Hyal Khurd about 6 miles north-east of Kellur, a small schist patch is observed.

(*d*) *North Himnur and Kongandi patches.*—About 4 miles from Marmakal to the north west, however, on the track between Himnur and Kongandi, a schist patch of about half a mile long and a quarter of a mile wide is noted, which shows a strike disposition of about N. 20° W. Similar hornblende patches occur to the north-east and north of Bilaspur near the main Surapur road.

(*e*) *Sardhalli patch* — Wider patches of schists, however, are seen in the Sardhalli area where the rocks are mostly epidioritic in character.

(*f*) *Umardoddi and Bantihal patches.*—To the north of Sagur, two comparatively broad hornblende schist masses occur near the villages Umardoddi and Bantihal. The former is a narrow band of about three miles long and a mile broad and consists mostly of fine grained schists with a strike of N. 10° W., and the latter occurs conspicuously to the south of Gugi. The best exposure of the Bantihal patch consists of a prominent belt of hornblende schists about five miles long and at its widest part about three miles, having a persistent N. 15° W. strike. The northern limit of this patch may be noted on the main road from Surapur to Gugi, and its southern, south of Nagnatki. Its eastern

margin lies close under the spurs of the Shahpur granitoid hills and the belt is traversed by a dolerite dyke south of Saidapur, which constitutes a conspicuous landmark over a wide area.

(2) *Manglur Band of Dharwars.*

This band forms a belt of hornblende schist extending from Bonal to Nagnur for a length of about 16 miles having an average width of about 3 miles, with an average strike of about N. 20 W. The band had attracted the attention of geologists and mining experts, as the Manglur Gold Mines, partly developed by the Hyderabad Deccan Mining Company, are situated on the belt. The schist has a rolling continuous course and attains to a height of about 1,600 ft. but gradually it descends down to the level of about the 1,300 ft. contour on the surrounding gneissic plain.

Outlying patches

Some outlying patches of Dharwars also occur marginally, the most important being along the eastern part at Godgira, Malgatti, Wandurg, Hosgiri, Shetigiri and near Badapur. In the Baichbal valley schist patches are also met with near Yediapur and south of Hadnur. A schist patch is noted on the track between Mudnur and Yediapur, and another on the Arikeri road near Yediapur.

Character of Manglur patches.

The schists of this band are similar in structure and character to the epidiorites of Wandalli and Topoldoddi of the north Maski band of hornblende schists. They are fine-grained, compact and indurated, much broken and jointed. Typical hornblende schists occur to the north and north-east of Parsanhalli and are well exposed on the Kembavi-Nagnur track. To the north of Godgihal, compact epidiorites with bouldery weathering occur, and near Vayur, hornblende schists.

Highly crushed lenses of schists are particularly numerous at Godihal where their denuded stumps are widely distributed. Here the marginal zone clearly reveals that a large portion of the Dharwarian rocks of the area has been subjected to severe shattering and removal. A few interlocked schist masses are all that now remain as entangled bodies in the gneisses.

Sometimes the schists are highly crushed and squeezed, and occasionally fragments of typical schists still lie as xenoliths entangled in acidic rocks. Such brecciated bands are noticed in the Wandurg Fort area (*Vide* Plate VI, photo 2), and in the surrounding country to the west of Hosgiri and of Shetigiri. The continuation of the Shetigiri exposure is traced to the west of Badapur. The patches at Badapur have only been given an approximate boundary but this does not indicate that such a boundary may be considered as the real junction with the gneisses. Only major patches have been indicated in the map, showing their structural relation.

Epidiorites.

Outliers of hybrid rocks have occasionally been mapped, the most notable being at Godgira and west and south of Malgatti. Intrusion of granitic rocks has often resulted in assimilation of schists and the rock thus formed runs in shreds and interlocked bands faintly preserving the original trend of the schists. On account of the broken character of the country these epidioritic outliers are only patchy, but, geologically considered, a great portion of it is clearly Dharwarian. Subsequent intrusions are so widespread that their real contact boundary with the gneisses is difficult to fix. The development of these reconstituted rocks is an outstanding structural characteristic of the eastern margin of the Manglur band.

Auriferous Quartz Veins.

In the Maski band of hornblende schists and elsewhere, quartz veins run in parallel disposition along the

foliation of the schists bands, which often pinch and swell in their course. They are sometimes auriferous. The veins show quartz, pale blue to slate-blue, in colour, sometimes mottled white and blue, and at times they are white and schistose. The reefs are mostly lodes of fissure veins.

Similarly, numerous quartz veins also occur in the Manglur band of schists and generally along its marginal portion though in the central belt they are not common. Blue quartz reefs are well seen north of Hagandoddi as far as Karadhalli and to the north of the same village. To the south of Hagandoddi on the track to Mavanmatti quartz reefs are also markedly exposed. The continuation of these quartz veins was further traced up to about 1½ miles south of Nagnur where they seem to have been cut off by a conspicuous dolerite dyke. Other quartz veins are noted to the north of this dolerite dyke mentioned above, to the south of Nagnur; but here the quartz debris derived from the quartz veins, does not give evidence of gold. Further continuity of the quartz veins is shown to the north-east of Khanapur, where white quartz-schists are conspicuous. All these quartzites are finally cut off near the hill .1621 where both the basic schists and the quartz veins are lost sight of under the black cotton soil. Some blue quartz reefs show a conspicuous run to the east of Mavanmatti on the track to Karadkal. Bands of quartz reefs could be identified to the north of Parasanhalli and on the footpath from Parasanhalli to Godihal. The quartz reef in the Parasanhalli exposure shows traces of gold when panned. Quartz reefs were noted in a series of runs on the western flank of the Manglur band on the footpath between Manglur and Karbur Talhatti, but the quartz is white in colour and appears to be barren.

Extensive fields of quartz debris are met with throughout the eastern margin of the belt of schists from Mavanmatti to the north of Karadhalli along the zone of blue

quartz reefs. Shallow depressions are noticed in these fields. These reefs and the quartz fragments occasionally show traces of gold. The depressions appear to be the sites of old gold workings, but there is no positive evidence of modern prospecting work having been done in this part of the belt.

Ancient Mine workings.

No knowledge is recorded of the people who made the first discovery of gold, but whoever, the ancient miners might have been, they were remarkably successful prospectors and it is probable that it was their activity that is still testified to by ancient workings.

In the olden days quartz reefs were followed down to water-level, sometimes more than 500 ft. deep, and rock pillars were left to support the walls. Prospecting was often done by circular vertical shafts, probably by fire-setting. Fire was lit against a working face and the heated rock shattered by quenching with water. Seeing the number of old workings now lying scattered over the field, it may be conjectured that the quantity of gold extracted by the ancient miners must have been large.

In the search for gold it must be borne in mind that these ancient prospectors worked so minutely in the areas that the possibility of finding exposed auriferous lodes in modern times is remote, unless the removal of the soil for ages, due to cultivation of the country, had exposed some auriferous reefs which the ancients did not find. Most probably the quartz reefs that we find now lying exposed, have already been worked and rejected by them as useless. This is one of the main difficulties with which a modern worker is confronted. It seems that the only chance left to a modern prospector is to unbottom these old workings and to continue to explore beyond the depth reached by the ancients. Undoubtedly they were handicapped for want of suitable pumping

arrangements which the modern worker can easily command.

Prospecting companies were attracted by the presence of gold, known by tradition to exist in the ancient workings at Hutti, where some valuable mines were actually found. This led to the exploration of all the gold-bearing blue quartz in the Raichur and Surapur taluqs, Gulbarga District, where the Dharwars exist.

The Hyderabad Deccan Company prospected in detail many old working sites in the Surapur area. The one south of Manglur and the other at a position marked as "Makan Gavi" north of the intersection hill .1466 are easily identified by the dumps of schists piled up in the places they worked. No encouraging report is known of the pit they sunk south of Manglur; but the "Makan Gavi" is reported to have proved a promising field. But on account of the Great European War in 1914, mining had to be closed down. This was the only mine after Hutti on which hope has been entertained.

Besides the two explored by the Hyderabad Development Company, other sites of old workings were also noted in the area. Of these, the following may here be mentioned:—

(1) To the south of Havanmatti, tracing a reef of blue quartz, a large scattered quartz spread was noted, apparently following a narrow low area. Fragments of quartz crushed and panned show traces of gold.

(2) To the north-east of Jinapur, a shallow depression was noted, with scattered quartz fragments round about it.

(3) On the west of the road to Karadhalli from Nagnur, south of a prominent dolerite dyke, a depression in the ground covered with quartz debris, apparently suggests a site of an old working. The quartz fragments strewn about the locality show traces of gold. All these sites deserve detailed prospecting.

Relative Age of the Auriferous Quartz Veins.

The eastern belt of the Manglur schist band is geologically noteworthy from two aspects :—

(1) Occurrence of blue quartz reefs and veins.

(2) Association of acidic binary rocks with quartz veins.

The western boundary of the Manglur band is well defined. Hard compact schists run as conspicuous ridges about 300 ft. above the level of the marginal gneissic area. But the eastern edge of the band is not so definite. Here the high rolling bands of schist descend into undulating flatter domes thickly strewn with fragments of blue quartz, crushed quartz, and white binary pegmatites. It is important to note that in this area a series of acidic rocks occurs, in which quartz reefs, which are at times auriferous, also play an important part. These acidics[1] are binary gneisses, pink pegmatites and graphic granites. Throughout this eastern margin flanking these rocks the reefs occupy the low hills running N. 10° W. in parallel bands and often ramifying into branches and stringers in the schist belt. Such veins are fairly persistent for miles but occasionally are lost sight of when they give place to spreads of scattered quartz fragments which, when powdered and panned, sometimes show traces of gold. Some even show visible gold in minute specks.

Attention[2] has already been drawn to the fact that most of the old auriferous working sites in the Maski band of Dharwars are confined to the margin of the hornblende schist belt near its junction with the Penin-

1. Similar acidic rocks have been described as " schisted acidic genisses " in the western portion of the Raichur Doab where these acidics have been suggested to be comparable to the " Champion Gneisses " of the Mysore Geologists. Journal, Hyderabad Geological Survey vol. III: Part 2 pages 55-58.

2. *Ibid* J.H.G.S. Vol. III Part 2, pages 63-65.

sular Gneisses, and that these sites are particularly crowded in zones where the gneisses penetrated through the schist belt and formed bays where pegmatites abound. For instance, on the western limit of the Maski band, the old working sites of gold are confined within the Hutti, Matbal and Maski bay-zones and those in the east and southern margin of the band, within Togoldinnin, Balganur and Saidapur bay-zones. The position of the old working sites at Kadoni is also interesting as being along the marginal area of the schists and pegmatoid gneisses. It would thus appear that this peripheral disposition of the auriferous quartz veins with the associated pegmatites may, perhaps, be regarded as something more than a mere accidental feature. More precisely, this would indicate that some of the pegmatites are very likely related to the auriferous quartz veins. The word "some" is advisedly used, as these pegmatites are not to be confused with the pegmatites of Peninsular Gneissic age. These Dharwar pegmatites are mostly schistose and found to be intimately foliated with the hornblende schists (*vide* Plate VI, photo 1). Their schistosity in the vicinity of old workings in the Raichur Doab is so characteristic that it is sufficient in itself to suggest their Dharwar affinity. But in no occurrences in the Raichur Doab are quartz veins found to have been formed as the end products of pegmatites. In this area of the Manglur band, however, we find pegmatites which pass to blue quartz veins (*vide* Plate VIII, photo 2). At times such quartz veins are also auriferous.

Thus it is that this relationship only indicates that these blue quartz veins are the products of differentiation of rocks of acid granitic affinity and so, incidentally, that the pegmatite-granites with which these quartz veins are associated or structurally involved, must be regarded as relatively older than the corresponding pegmatites and granites of the Peninsular Gneissic group. It may therefore be perhaps possible to suggest that the auri-

ferous activity of the quartz veins must have taken place at an age when the acidic binary rocks of this area were intruded.

Structural aspect of the Dharwars.

Before concluding this section, a few facts may also be added regarding the general structural aspect of the Dharwar belts in relation to the Peninsular Gneissic rocks.

The irregular shape and the strike of the Dharwar belt, south of the Kistna, in relation to the alignment of the gneissic hills in the Raichur Doab, has already been alluded to.[1] It has been pointed out there that this structural disposition of the hornblende schist band may well be attributed to earth stresses necessarily involved in the intrusion of the gneisses, producing a parallel feature with the schists. Analogous relations of similar dynamic significance may also here be compared in the Shahpur and Surapur area under report.

(1) The alignment of Surapur hills marked .1886, reaching to Sugurappa Gutta .1695, which borders the eastern margin of the schist band, is a point demonstrating this structural bearing.

(2) The Dharwars which occur as fragments and brecciated masses in the Wandrug area north of the intersection hill .1634 bear strong testimony to effects of crushing produced by gneissic invasion.

(3) The association of Dharwar schists resulting in epidioritic rocks west of Diggi or Saidapur, with the Shahpur group of gneissic hills is an interesting fact.

(4) At the margin of the gneissic hills at Warapur or Umardoddi the original Dharwar rocks have been

1. Journal, Hyderabad Geological Survey, Vol. III. Part 1, pages 50-51.

crumpled and squeezed into narrow bands of which only a denuded strip now remains.

(5) The epidioritic schist patches at Naikal may also be noted in this connection in relation to the neighbouring granite hills with which they are structurally associated.

Peninsular Gneissic Complex.

By far the greatest portion of the area consists of the Peninsular Gneissic Complex. It is not intended to go into the details of its classification or description of the types met with in these parts, as they are very similar to those examined and reported on from the Raichur Doab.

The broad classification of the Peninsular Complex into the grey and the pink series with their respective sets of pegmatites and quartz reefs holds good also in the area under consideration. The pink members are only limited to the north Kistna basin where the porphyritic types occur in great force. These pink members occur to the south of the area under report.

Gneisses of the hilly tracts of the central belt of Surapur & Shahpur Taluqs.

The grey series has the most prominent development in this area and occurs as the hilly tracts of north Surapur and Shahpur. The rocks are very often hornblendic, though biotite gneisses are not uncommon. It is seen in some places, as in the great *massifs* of the Shahpur and Surapur hills, that the grey members pass imperceptibly into pink varieties. Pink fine-grained gneisses occur extensively to the north of Sagar and Rastapur.

There are numerous pegmatite veins, aplitic runs and quartz veins traversing the grey gneissic country. The pink and red pegmatites occur particularly along the Dharwar margins of the Manglur band of schists.

Peninsular Gneissic Complex in the Kistna basin.

The grey series of gneisses are represented by the white biotite-gneisses and the micaceous schistose types in the Kistna basin of the Shahpur taluq in the tract of country to the south of the main road from Surapur to Yadgir near Birnur and Madarkal. On weathering, these micaceous gneisses often exhibit fissile structure simulating laminated schists, being characterised by bandings and marked by exfoliating weathering. Pink gneisses are not found within this area, but coarse pink pegmatites are very commonly observed.

The other variety of gneisses mostly in evidence is represented by white binary pegmatites. On weathering, these white binaries give rise to gritty calcareous detrital deposits in the low valleys and *nala* beds.

Coarse grey granites are frequently met with and they are traversed by numerous joints and cracks subsequently filled in with calcareous infiltration products. Wells sunk in such coarse granitic rocks have proved very satisfactory for irrigation purposes affording a good supply of drinkable water, *e.g.*, (1) Birnur irrigation well, (2) Madarkal drinking water well.

Quartz reefs.

Quartz reefs of huge dimensions have rarely been noticed in this area except a few in the eastern zone.

(1) One important quartz reef occurs at Marmakal, terminating to the north of the village. Its continuation may be traced south-south-west about two miles away on the hill. 1305.

(2) The other quartz reef is noted at Khanapur about twelve miles from Yadgir Railway Station and its continuation at Gundhalli, on the main road to Shahpur from Yadgir. Advantage has been taken of these two reefs to utilise them as the natural dams for two important tanks constructed in the areas by the Public Works Department.

(3) One minor quartz reef was noted about two miles north-north-east of Tumkur. 1231.

(4) Some quartz reefs of huge dimensions have been noted along the eastern border of the Manglur band of Dharwar schists in the Surapur hill tracts. These occur in parallel runs from north of Karadhalli in broken continuity up to the west of Nagnur near to a quarter of a mile south of hill. 1621.

Salinity in relation to Rocks.

Pegmatites and their relation to salinity.

The pegmatitic occurrences in the Bhima valley west of the Manglur band are particularly interesting, as they form a prominent zone of salinity. The Baichbal-Tegheri and Kudligi saline areas are situated in a thickly soil-covered country at the marginal belt of such pegmatite occurrences. There is very little doubt that these pegmatitic rocks form the base of the area, though wells of more than 100 ft. in depth do not expose the underlying rock. However, some of the rock sections studied in the area during previous field seasons amply testify to the occurrence of the pink binaries in the saline zones.

Calcareous accumulations.

The accumulation of huge deposits of calcareous loamy material in close association with these pink members is a noteworthy feature. The significance of such occurrences of pegmatites and associations of calcareous deposits in saline zones need not be dilated upon here as this had already formed the subject-matter in a previous Journal of the Department.

Similar association of the pink binaries with the saline tracts of the eastern portion of the area under report, is also to be noted.

Auriferous Dharwars in relation to salinity.

One interesting feature regarding the association of such pegmatites and quartz reefs along the junction zone of the Manglur band is worth mentioning. As already stated, the Manglur band is only a continuation of the Maski-Hutti band of Dharwars of the Raichur Doab and is equally auriferous. The association of salinity with this auriferous zone of the Maski band finds a confirmation in this area as well.

Is salinity due to chemical precipitation.

But the close proximity of the Bhima Series seems to give a plausible argument for the salinity of the area being due to some chemical precipitates of the 'Bhima Lake.' But this may perhaps be overruled by the fact that numerous wells which have been examined within the different formations of the Bhima Series, from their basement beds upwards in this valley, have invariably yielded sweet water. And this close proximity of the Bhima sedimentaries would give any one unfamiliar with the area an erroneous idea of attributing the salinity wholly to the chemical precipitates. But this assumption would not be found tenable in view of the fact that the wells in the saline zones rapidly deteriorate in the strength of brine if heavily drawn upon. If a bed of salt was the source of brine, it is impossible to account for this rapid fall in brine density. This is the experience of all the salt makers of the area and they take every care to see that no one well is drawn so constantly and completely as to deplete its zone of slow percolation.

Salinity is largely superficial.

The fact that the brine-wells in the area are situated only in the thick soil mantle points to the salinity being due to superficial causes. The Baichbal valley is particularly characterised by a very thick mantle of black cotton soil sometimes attaining to more than 100 ft. in depth. The surface salinity due to such a huge accumulation

of soil, should not be underestimated in this area, unlike the Raichur Doab where the soil mantle is only a few feet thick. The migration of the more soluble salts in solution towards lower zones in the course of meteoric circulation has already been referred to in my previous note.[1] It has been clearly shown from the quality of brine from Baichbal and that from Chikahaval zone, that the Baichbal area produces good edible salt with maximum percentage of NaCl, whereas the Chikahaval zone nearer to the Kistna, situated at a lower level, produces mostly tanning salt in which the more soluble ingredients such as $MgSo_4$, and $MgCl_2$, predominate.

Bhima Series.

The Bhima Series of Purana rocks occurs to the western end of the area under consideration, overlain by the Deccan Trap towards the western extremity practically following the State boundary. In its widest portion the sedimentaries are 7 or 8 miles wide. The whole belt is crescent-shaped, with the concavity towards the east.

Limit of Bhima exposure.

A very interesting structural feature of these formations is the occurrence of a number of outliers of limestones overlying shales in many places between the present boundary of the sedimentaries and the Dharwar boundary of the Manglur band towards the east. These smaller outliers and patches of limestones rest unconformably on the gneisses and are for the most part broken up, testifying to the enormous effect of denuding agencies which must have removed a greater part of the once continuous formation. The soft nature of the underlying film of shale beds must have facilitated their removal. The present boundary of the Bhimas,

1. Journal, Hyderabad Geological Survey, Vol. I. Part 2, page 159.

therefore, does not seem to show the original extent of the deposition, which must have extended beyond, so to cover the area now occupied by the outliers at least up to the limits of the Dharwarian highlands, now represented as remnants by the Manglur band.

Similarly, the boundary of the sedimentaries on the north also probably extended further south.

It is, therefore, very likely that the zigzag line, roughly along the western boundary of the Manglur band, which if produced eastwards would meet the Dharwar band south of Gugi, may probably represent the original limit of deposition of the Bhima sedimentaries. This assumption is supported by the alignment of the Surapur and Shahpur gneissic hill ridges, which form a sort of horse-shoe plateau with its apex somewhere in the Budnur-Chandapur-Rajapur limit, which, though now a comparatively lower land, must have been of much higher elevation during Bhima times but since have been denuded away. That such regional denudation has played a part in these areas is evidenced by the remnants of numerous minor patches of Dharwars still lying enguifed in the gneissic core of the hills. The secular depression and upheaval of the adjacent Bhima basin should no doubt be considered as being responsible, at least partly, for the great denudation of the country. The small limestone outliers east of Dwaranhalli suggest a further lower limit of the Bhima basin.

The Bhima Series of sedimentaries lies unconformably on the Peninsular Complex though possible extensions of the Dharwar below the Bhimas are indicated. The series as a whole is about 200 to 300 ft. thick composed of the lower shales and an upper limestone series. The Bhimas, as they are exposed, are essentially a limestone formation, though shales *in situ*, are seen to occur away from the limestones to the north of Kembhavi.

The succession of the beds of the Bhima Series may be given as follows :—

(4) Limestones.
(3) Shales.
(2) Quartzitic sandstones.
(1) Conglomerates.

(1) *Conglomerates.*

The basal conglomerate beds are very rarely developed. In fact no exposures *in situ* of conglomerates were noticed in the course of the survey, but the occurrences of gravel beds seem to suggest a possible original deposition of the conglomerates which have been subsequently broken up and carried to a lower level. If the conglomerates occurred at all they could not have been of any wide extension and were perhaps limited only to narrow fringing belts.

(2) *Quartzitic Sandstones.*

The quartzitic sandstones are not very widely exposed. They are mostly gritty and felspathic, and horizontally bedded. Only at the flanks of the shale beds, in a few places, obscured by the black cotton soil, are they seen. They are usually quartzitic in character, unmappable in extent and have been included within the shale beds. Their best exposures were noted :—

(1) to the north-west and west of Kachanknur,

(2) to the north-west of Agni, in small rises,

(3) to the east of Kembhavi about a mile to the east, on the Nagnur and Parasanhalli tracks, and

(4) in a few other minor exposures near Kadihalli.

These beds usually abut against the gneisses conformably overlain by the shales.

(3) *Shales.*

The shale beds occur conformably overlying the sandstones though, as already mentioned, it has not been possible to trace a regular occurrence of sandstones everywhere below the shales.

The upper layers of the shale beds show intercalcated limestones, which become more and more numerous as the topmost horizon of the shales is attained, until finally they pass into the typical limestone series.

These shale beds are mostly pale pink in colour, though rarely a greenish variety also occurs. They are friable and laminated and at times intercalated with shaly limestones. In their best development the shales are about 100 ft. thick. All along their exposures they are mostly marked as shelving ledges to the limestones, which occupy higher contours. In fact, when looking from the gneissic valley of the lower contour, these shale beds appear as a barrier of about 100 ft. high, as it were a rampart of a fort, and run for miles and miles through the country, capped by a flat trace of limestones which control the topography of the area. On account of their uniform resistance to denudation, these limestone beds end abruptly against the softer beds of shales, which suddenly drop down to the lower contours of the main gneissic valley. The boundary between the gneisses and the shale beds could be only approximately-mapped, as it is covered with soil.

The country between the 1,400 ft. and 1,500 ft. contours is usually represented by the shale beds, which fact has often facilitated the tracing of their boundary.

Calcareous beds.

In many places the shale beds give place to calcareous clayey formations. Such exposures are particularly noticeable in the area to the east of Mudnur, between Mudnur and Rampur, and on the track between Mudnur and

Yadiapur. Two diverse processes seem to have contributed to their accumulation :

(1) Decomposition and dissolution of the limestone beds.

(2) Decomposition and disintegration of pegmatites and aplites of the gneissic area.

(1) The calcareous earthy beds between Mudnur and Rampur occur over a mile in length and about two furlongs in width and seem to be of the nature of travertine deposits resulting from the action of springs once prevalent in the area. Springs are even now observed in Mudnur but they are mostly dying out.

(2) These pegmatites are exposed in the central valley in the triangular area lying within Mudnur, Yadiapur and Kembhavi. A few shreds of Dharwar schists are also associated with them, buried in a thick deposit of the black cotton soil. The pegmatite rocks are interesting. The wells in the adjoining area are saline; and the surface and underground drainage of the area collect in the lower valleys of Baichbal and Kudligi where salt works are much in evidence.

Calcareous deposits of the gneissic origin at times included with the boundary of the shale beds.

In places, calcareous deposits, derived from gneissic rocks, have often been included with the shale beds; being indistinguishable from deposits from limestone formations.

Malla Buzurg shales.

In most places, except at the scarp edges, the limestones rest on shales, which are finely laminated pink friable formations, rarely greenish in colour. In the nala cuttings and in natural sections along cart-tracks, the shale beds show only 5 to 10 ft. of thickness and their surface extensions are greatly obscured by the overlying migrating soil spreads. This being the case, the limits outlined in the map of the shale beds are at best approximate surmises.

(4) *Limestones.*

The limestones lie conformably over the shales and, as already indicated, form the chief constituent rock of the Bhima Series. They are found to occur above the 1,600 ft. contour and in their maximum development attain to a thickness of about 100 to 150 ft. The mapping of the limestone boundary is facilitated by its peculiar plateau-like aspect, which marks it off even from a distance. They are mostly of grey or drab colours, though pink, brown, mottled and cream-coloured varieties are not uncommon. The limestones are highly indurated, fine-grained and flaggy; massive varieties also occur, which do not allow easy splitting into slabs. The finer flaggy layers appear to be the purer varieties, whereas the massive types are more siliceous.

These beds are particularly well seen on the 1,500 ft. contour, which in fact clearly defines the boundary of the limestone beds at the fringe of the shale beds. Between the 1,500 and 1,700 contours the exposures are mostly limestones, overlain by Deccan trap flows which latter reach above 1,800 ft. in many places.

Mudnur limestones.

Directly above the shale beds, the limestones are earthy, pitted and splintery and marked with shallow holes. At the junction blocks of limestone lie higgledy-piggledy, due to the removal of the underlying softer shales. In typical areas they exhibit bedded structure and split into blocks and slabs, used for flooring, usually 5′ × 3′ × 6′ in thickness. Rudely dressed blocks are used for walls and minor pavements. Laminated limestones are quarried by *waddars* for local use. Thin slabs of suitable dimensions for flooring purposes are not widely found; only the massive variety is met with at the marginal zone.

Springs.

Warped by shrinkage, the limestones are occasionally intersected by cracks and joints. By the passage of water such fissures widen to form numerous swallow-holes underneath.

Huge underground channels are at times developed under the action of water which ultimately finds an exit, at the top of the shale beds as surface springs. At Mudnur, at the contact of the shales and limestones, such springs constitute the main source of water-supply of the village. More than 64 acres of land are cultivated at Mudnur under one of the principal springs. Streams fed by such springs keep up a perennial supply near the village. At Mullah Buzurg, at the junction of the limestones and gneisses, springs feed a perennial stream.

Outliers of limestones.

In the Baichbal valley, outliers of limestones are also noted, but they are mostly too small to map and so have been generally omitted.

At Yelgi a limestone outlier underlain by pink shales is met with on the cart-track from Yelgi to Gogdihal. The Yediapur outlier patch occurs to the south of Yediapur reaching to the south of Kudligi in an irregular shape about 2 furlongs broad and 3 miles long. Here the limestone mass consists of broken fragments deeply buried in the soil.

Yedihalli outlier.

This outlier is a triangular patch of cherty limestone which occurs as splintery masses in broken fragments all lying in a confused manner. The pink shales underlie the limestones to the east. On the west, brecciated masses occur directly resting on the gneisses. The structure of this patch is perhaps easily explained on the supposition that the softer underlying shaly sandstone beds have been removed by undercutting.

Weathering.

One characteristic weathering feature common in the area, is shown by a large number of swallow-holes distributed irregularly on the surface of the limestones. These holes vary from less than half an inch to an inch or more in diameter and appear like fossil burrows and rain

drips. They, however, do not extend more than 3 or 4 inches in depth and are mostly superficial.

These limestones are extensively quarried for house-building, flooring and other purposes. It is needless to mention here their importance as raw material for cement manufacture, which fact has already been proved by the Shahabad Cement Works.

Succession of Beds.

Taking a bird's-eye view of the sedimentary series, their regularity of deposition, without any appreciable break, suggests quiet times during which there was a continuous deposition of the rocks in the 'Bhima Lake.' Thus we find a succession of the whole formation in one continuous group from its lowest to its topmost beds exposed in many places along the present escarpment of the Bhima rocks.

But the occurrence of wide-spread limestone beds along the southern boundary of the Bhima basin between Kembhavi and Gugi directly on the gneisses would show that there was an extensive overlap of limestones. Bruce Foote has classed the limestones with the Upper Bhima Series and the conglomerates, sandstones and shales with the Lower Bhima series.

Structural Disturbances at the Margin of the Bhima Beds.

A landslip is shown by a hill about one mile to the north-east of Sadbul .1554, which consists of broken fragments of limestones lying heaped up in complete confusion on the gneisses.

Another such disturbance is indicated by the broken piles of limestones and trap in the section exposed in the Agirthi *nullah* near Agni.

Another structural feature may be noted on the track from Agni to Mudnur, about half a mile from Agni,

where a red quartzitic sandstone hill is exposed. This bed lies at the same level as the adjoining limestone beds to the south and west of the exposure. This horizontality in level between the older and the younger beds easily suggests the occurrence of a fault at the place. The presence of debris of limestones and trap which occurs in profusion in the lower valley to the east of this area perhaps supports this possibility.

At Gugi, limestones occur at a lower level in juxtaposition with pink or purple shales which latter occur at a higher zone. The shale beds, however, when traced further west are found to lie in juxtaposition with limestones near Dharanhalli at the same level. This would suggest that some faulting or landslip must have resulted by which the limestones have been displaced to a lower level.

Deccan Trap.

Only a small extent of the huge Deccan Trap plateau comes within the area under report.

These formations extend towards the western portion of the area fringing the State border from Gundalgeri and Karibhavi in the south to Wandagnur in the north for a distance of about 14 miles. In its widest extension it is about 7 miles in width within the State limits.

One outlier of the Deccan Trap has been observed about 2 miles west of Hadnur. About a mile south of Salgundi a fringe of the northern boundary of a trap outlier is marked. A smaller outlier forms . 1780 about 2 miles south-west of Arikari.

Contact.

These formations rest on the denuded surface of the Bhima limestones as a terraced plateau. All along the margin of its boundary from west of Agni to Wandagnur the trap directly overlies the limestone beds. But on the

track between Gundalgeri and Sadbu, the limestones are largely broken up and the trap rests directly on the denuded surface of the shale beds and decomposing gneisses.

A white calcareous earth is found at or near the junction, wherever the Deccan Trap overlies the gneisses. Such calcareous products are frequently met with along the footpath from Gundalgeri to Agni. Here the limestones have been largely broken up and the shale beds are exposed as denuded flats.

These trappean formations are usually met with above the 1,700 ft. contour and are easily recognisable even from a distance. The flows do not show any lateritic alteration and appear fresh, being mostly of a hard, fine-grained basalt weathering into spherical bouldery masses. Vesicular and amygdaloidal varieties are very rare. Zeolites and other secondary minerals are absent in this trap. The green earthy decomposed upper layer of the trap beds is usually a barren and uncultivated waste.

The marginal trap flows occur in layers and spread in sinuous outlines over the limestone beds and gneissic rocks upon which they rest. Some thin trap layers split into blocks and ultimately form boulders. The contact zone of limestones and trap is often marked by such boulders. They accumulate in places into extensive deposits along high slopes and by the action of water are carried down to the lower valleys where they are buried in the migrating soil. Such boulders are often met with miles away from their place of origin, in association with gneissic, quartzitic and limestone fragments.

Dykes.

Directionally these dykes may be mainly divided into two groups, namely :—

(1) The north-east dykes.

(2) The north-west dykes.

Very rarely some have an east to west trend.

One of the longest dykes of the area, the Molhalli-Chandapur dyke, cuts right across the Manglur band of schists. The other dykes of importance are :—

(1) The Aldhal-Sagar dyke.

(2) The Surapur group of dykes.

(3) The Dwaranhalli-Handikal dyke.

The others are of minor magnitude and in shorter, interrupted lengths. Most of them, specially those occurring near the confluence of the Kistna and the Bhima, are found to run over a few furlongs only, being lost sight of in the soil-cover.

One important feature of structural significance in the Surapur-Wandrug hill tracts is perhaps indicated by the occurrence of a large number of dykes in that region. A glance at the map will show that this part of the hilly tract is particularly crowded with dykes which traverse along both the prominent directions mentioned above.

The south-west group of Shahpur gneissic hills is characterised by a run of a prominent dyke extending from near Rastapur to about two miles south of Gugi.

These dykes are mostly doleritic in character though rarely porphyritic types are developed, as at Handikal. The Handikal dyke shows a peculiar contact effect with the adjacent gneisses where an epidioritic phase of rock is developed with ribbed and contorted weathering, similar to the epidiorites at the hornblende schist margin.

Some of the minor runs of dykes to the east of the area, for instance those in the vicinity of the pebble beds, show a fine-grained epidioritic character and appear to be different from the normal dolerite dykes. Fragments of these occur with the pebble beds.

Old Kistna and Bhima Alluvium.

Gravels are largely met with along the cart-tracks between Birnur to Kellur, Baswantapur and Madarkal, Hyal Khurd and Hyal Buzurg and Ikur. Similar gravels occur in the gneissic area, mostly consisting of quartzitic fragments. Their extent is approximately indicated on the map. These beds consist mostly of chert, chalcedony, quartzites, gneissic fragments and, very rarely, limestone and epidiorite. In size the pebbles vary from 5″ to 1″ in diameter and are not much water-worn but mostly angular.

Their derivation is due to the action of old streams transporting materials during floods. The annual local cultivation and the frequent washing away of the black cotton soil brings them to the surface.

Gravel spreads are also found in isolated patches along the north bank of the Kistna. They were noted to the west of Gundianur and Chinnur, north of Tumkur, north of Konal and Sangam.

Kistna pebbles

The association of these beds with the loops and bends of the course of the Kistna may be particularly noted. Their occurrences, as at Chinnur and Gundianur, easily suggest their possible transportation by the high flood action of the Kistna. At Gundianur a bed of cherty gravels occurs in great force in association with pebbles of quartz, cherty quartzites and fragments of gneisses on the high bank of the river. On the track from Konal to Chinnur similar cherty gravels are profusely scattered along the north bank.

The gravel beds are situated so high above the present high flood level of the Kistna that it is obviously difficult to ascribe them to the floods of the recent period. Its present bed level is the result of its own erosion in the past. Their presence, therefore, at levels

much higher than the present high flood level is to be accounted in the fact that the gravels are merely the relics of the high flood terraces before the river had cut its bed to its present depth.

Bhima pebbles.

Similar pebble spreads near Birnal and Gudihal on the west bank of the Bhima, may also be easily connected with the past floods of the Bhima river.

Soils.

The soils of the area under report may be divided into two broad groups, namely:

(*a*) Black cotton soil group.

(*b*) Gneissic soil group.

No regular soil survey has been attempted. The main criterion for the approximate tracing of the soil boundary is its colour. Thus a rough distribution of the soil is here indicated.

(*a*) Black cotton soil.

By far the greater part of the country is covered with black cotton soil, which occurs in three broad belts, *viz.*,

(1) to the west of the gneisses of the Central Surapur hilly region, west of the Manglur band, covering the Baichbal valley as well as on and along the fringe of the limestone formations, and on the traps,

(2) along Kene-Kellur and Sagar-Birnur *nala* basins and

(3) along the western bank of the Bhima river reaching to its confluence with the Kistna.

The soil derived from grey basic gneisses is grouped under the black cotton soil as the former passes through various shades of colour and coarseness ultimately grading into typical black cotton soil.

It will be seen that the black cotton soil occupies the :

(*a*) the limestone plateau lying within the 1,700 to 1,400 ft. contours to the west and north of the Baichbal valley,

(*b*) the lower Baichbal valleys within the 1,500 to 1,300 ft. contours from near Kembhavi to Baichbal,

(*c*) the Shahpur valley within 1,400 to below 1,200 ft. contours from Shahpur to Himnur, and

(*d*) the Bhima valley within 1,200 to 1,100 ft. contours.

The gneissic soil on the other hand, occupies levels between the 1,800 ft. and 1,900 feet contours in Shorapur hill tracts and between 1,400 ft. to 1,200 ft in Wadgira-Tumkur area, where some of the hills reach 1,672 ft. above the sea-level.

Thus, it is clear that the black cotton soil occupies all levels between 1,700 to 1,100 ft. contours, and that it does not necessarily occur in all the levels on which the *in situ* gneissic soils prevail, although such levels favour their accumulation elsewhere. This difference in distribution clearly suggests a shifting character to the black cotton soils, the migration being controlled by the valleys and slopes which regulate their formation and transportation.

By comparing many of the wells and natural sections of the area it may be shown that the depth of the black cotton soil varies from a few inches in some places to 10 to 15 ft. in others. In wide areas where the underlying rock is regulated by a slope, its depth increases with the gradient. Otherwise the soil lies as a thin black or steel grey mantling bed upon gneisses and pegmatites. In somewhat deeper *nala* cuttings, this soil may frequently be observed, particularly in the lower sections of the banks, to consist of greyish arenaceous layers in stratified disposition intercalcated with black

clayey bands. But on towards the upper portions of the *nala*, only unstratified clayey deposits occur, mixed up with *kunkar* nodules. Even along the larger river banks such as the Kellur *nala*, terracing features of sedimentation are not seen, the soil being more or less residual in its character, accumulated by rain wash. Consequent on the inequalities of the surface drainage and the irregular mode of distribution, the soil at times rests on decomposed acid gneisses and pegmatites, often mistaken for residuary *kunkar* deposits. Closer inspection, however, reveals that such deposits are due partly to the incomplete decomposition of the rocks *in situ* and partly to infiltration of water charged with calcium carbonate.

A few remarks may be added here regarding the origin of the black cotton soil. As in the Raichur Doab, it is not necessary to assign the origin of the black cotton soil only to the decomposition and disintegration of the Deccan Trap. The materials necessary for the formation of the black cotton soil are sufficiently accounted for by the presence of the innumerable Dharwar patches, besides basic gneisses and basic dykes. But there appears to be no means to decide the relative proportion of the material supplied by both the Deccan Traps and the Dharwars and the other basic rocks, towards the formation of the black cotton soil of this area. There is very little doubt that the Bhima shales must have also contributed towards the proportion of clay in the soil. Thus the close proximity of all these three formations, *viz.*, trap, schist and shales, in the Baichbal Valley, presents an additional problem towards the determination of their relative share in contribution to the formation of the black cotton soil. It is, however, apparent that all the three types must have contributed towards the formation of this unusually thick mantle of about 100 ft. in the Baichbal area.

The presence of black cotton soil on the limestone area adjoining the Deccan Trap may easily be explained

by its being a weathered product from the trap itself, which has travelled on to the limestone.

(*b*) Gneissic soil.

Two main belts of gneissic soils separate the black cotton soil zones, namely:

(1) belt, represented by the Shahpur hill tracts and further south-west, covering the whole range of hills north and west of Surapur.

(2) belt, represented by the Wadgira-Tumkur area.

A large number of pegmatite dykes cut through the gneisses and the schists. As they are mostly rocks consisting of quartz and feldspar only, decomposition of the latter and disintegration of the former are the usual lines of weathering in such rocks. As they usually occupy low levels, meteoric water is effective for the liberation of SiO_2 and formation of hydrous oxides and silicates of aluminium and iron and soluble alkaline carbonates. Wells sunk in such pegmatites have in many cases yielded saline water.

(1) Grey gneissic soil.

As has already been pointed out, this type of soil is included with the black cotton type of soil, both on account of its colour and the various gradations through which the soil passes.

This grey soil is generally confined to the valley portions in the proximity of hills composed of basic granitoid gneisses with predominant ferromagnesian constituents such as hornblende and mica and is wide-spread, practically fringing the plateau hills of Shahpur and Surapur. As these gneisses are to a large extent cut by quartz veins and minor intrusions, numerous cracks and joints favour their disintegration *in situ*.

(2) Red soil.

Extensive areas of red soil are met with on gneissic areas, such as south of Rabanhalli to the west of Gugi and north of Kurkundi to the south of Khanapur. They occur in force, in zones where dykes, basic gneisses

and epidioritic rocks occur. This soil is comparatively fertile and well suited for crops which require good soil drainage.

(3) Sandy soil.

This soil is met with between Tawar Wadgira and Kurkundi and south of Wadgira and north of Kurbihal and many other places. Such areas are poorly cultivated. To bring it under cultivation villagers often mix this soil with the requisite quantity of clay and manure. Occasionally the sand shifts as blown dunes and the ryots protect their fields by fencing with suitable plants.

(4) Calcareous loam.

This soil is developed when the grey gneissic soil is highly calcareous and is abundantly found in the area north of Diggi, Shahpur, Naikal and other places. This is a fine silty loam with preponderating calcareous material and occurs along the fringe of the Bhima limestone area.

Alluvium.

Recent flats are formed in the bed of the Kistna and the Bhima, particularly at or near the loops and bends as they meander in their courses and deposit their load of suspended silt where the flow of water is sluggish.

During floods, gravel beds are also laid down upon the flats of the silty mud left behind on the retreat of the water. These are further overlain by sandy loam carried down during subsequent freshets. Thus, thin silty layers alternating with pebble beds and arenaceous intercalations are frequently deposited as the river alluvium. Sand-banks are constantly shifting. Many tributary streams carrying volumes of spoils of the soil and rock often contribute to the formation of mud-flats when emptying their argillaceous load in the main rivers.

Recent silt also accumulates in the beds of tanks and shallow basins where the rain-water collects as surface

drainage. Saline and calcareous residues often appear in the beds of drying tanks at their waters' edge.

Usually where the date palm and shrubby bushes grow wild, in cooler and humid tracts in the sheltered meanders of many streams, soda-earth and fine calcareous silts especially at the edge of drying pools, are frequently formed as an efflorescent crust. Here salts carried underground in solution also reappear on the surface by capillary action, adding much to such encrustations.

Residual calcareous crusts, sometimes miles in length, are deposited along the banks of the Kistna south of Kellur, probably being due to the washing away of the mantling black cotton soil. Sometimes the *kunkar* thus formed alternates with arenaceous layers. In other places in the midst of the black cotton soil plain, due to migration of surface soil, calcareous sub soil layers often lie exposed, hard and impervious and unfit for cultivation. The barren tracts to the south-west of Gudesugur west of the track from Halgiri to Hulkal is an instance.

Kistna-Bhima Doab.

Pluvial origin.

The tract bounded by the Kistna-Bhima Doab, comprising the eastern zone of the area under report, is essentially a country of pluvial origin. Past drainage is not necessarily reflected in the reliefs presented by a comparatively recent surface topography. But the present is a key to the past.

The schist patches, away from the main Dharwar band, clearly show that the Dharwars, which were once extensive, are now almost totally removed by long continued weathering. Similarly, the presence of isolated gneissic ridges and knobs testifies to an extensive denudation. The dykes that occur in this area are mostly small. Difficulty was often found in tracing them, as they lie mostly concealed in the soil, thus indicating an extensive accumulation of the soil-mantle covering past

topography. The gravel beds in the Kistna and Bhima basin have already been referred to. There are no indications in the area to suggest any secular oscillations in level in the later geological times subsequent to the Deccan Trap period. The loops and bends in the Kistna are favourable for the accumulation of gravels. The Kistna must have changed its course owing to barriers. Thus the gravels above the present flood levels about a mile on the north bank of the Kistna may be accounted for. Similarly, the gravels on the bank of the Bhima river and further west of Bhima near Naikal, also indicate similar changes in the course of the Bhima river.

The occurrence of pebbles to the west of Wadgira suggests the action of past streams which carried the local gneissic debris, cherty fragments, limestone and trap. The presence of limestone with the pebble beds, though rare in Madarkal and south of Hyal Khurd, indicates their derivation through stream-transport carrying material from higher reaches where the Bhima beds existed.

Thus, on the whole, it appears that the tract between the Kistna and the Bhima to the east of the Shahpur and Surapur hills may be regarded as due to the pluvial action of the main rivers, Kistna and Bhima, supplemented by the activities of past streams now either disappeared or deviated in their courses. The country is so thickly covered with black cotton soil that its presence has now totally masked the effects of past pluvial action which contributed to the shaping of the present topography.

Economics.

Gold.

The extension of the Maski-Hutti band of Dharwars in the Surapur taluq, referred to as the Manglur band, has already been described. Attention was drawn to

the auriferous nature of the band and reference made to the prospecting companies who opened out the old workings now known as the Manglur Mines. Without going into details, the following facts may be summarised.

The activities of the Deccan Development Company was mainly confined within two centres of old workings known as :—

(1) Brahmin Well workings,

(2) The main North-Station workings (Makenghavi).

(1) Brahmin Well workings.

A run of old workings was noted just north of Brahmin Well, south of Manglur Road, for a distance of over 1,200 ft., and this was prospected by pits and trenches, quartz from which gave encouraging assays. A shaft was sunk in the Brahmin Well itself to a depth of about 220 ft. and drives were also put in. It appears from the reports that though the quartz gave encouraging assays in the higher levels, the lode pinched out with poor assay values in depth.

(2) North-Station Working, (Makenghavi).

An extensive old working site in parallel runs was discovered near Makenghavi, which received detailed attention. Two shafts were sunk, one known as the Mandic shaft on the eastern old workings and the other, known as the Holman shaft, further south of former. Drives were also provided in both the shafts. It appears from the prospecting work that a lode was discovered in this field. This shoot gradually but persistently increased in value and extended in length as it was followed to the depth. As the activities of the company had to cease with the outbreak of war in 1914, the full potentialities of this field still await investigation.

In the course of the present survey a few more old workings on the eastern flank of the Manglur band were also noted and an enlarged map (*vide* Plate I) of the band

was prepared, showing the old workings as well as the quartz veins and stringers that traverse the area. These were followed on the surface and samples panned. Some of them gave indications of gold.

In view of the indications obtained during the recent survey and of the encouraging results of the activities of the prospecting companies and specially the favourable opinion expressed by the mining experts who worked on the area, it would appear that this field deserves detailed prospecting. It is also hoped that this may lead to a revival of gold mining in the area.

Haematite quartzites, Hill .1621.

To the north of Nagnur to the west of the track to Malla Buzurg, a quartzite hill occurs. This quartzite band is pinkish, mottled with younger veins of white quartz impregnated with hæmatite ore. The quartzite is structurally and in sequence comparable to the Chincholi and Machnur quartzites in the Raichur Doab (*vide* Plate VIII Photo 1).

Pyrite.

About two miles south of Yelgi, in a *nala* by the side of the footpath from Yelgi to Fatepur, pyrite occurs sporadically distributed in limestones. The upper layers of the limestone contain pyrite in appreciable quantity, but the lower beds are practically free from it. The occurrence, therefore, does not seem to be economically important.

Muscovite.

To the south of the quartzite hill .1621, a white quartz reef occurs. Some muscovite bearing fragments of quartz were picked up in the field where the reef crops out.

Since writing this report prospecting of the Maski-Hutti and Manglur areas has been taken up by Messrs. John Taylor & Sons, Ltd., under the control of H.E.H. the Nizam's Railway Board, financed by the Government. The village-reef shaft near Hutti is being dewatered and active deep diamond-drilling operations are progressing in the Manglur area. The results of this prospecting work are watched with close interest.

The continuity of this quartz reef could be traced, cutting the track to Kembhavi from Nagnur, where no trace of muscovite was discernible. But to the south of Nagnur, about half a mile from the village on the Hagandoddi track, in the broken fragments of float quartz, muscovite mica was again seen. Apparently, however, the indications are not very favourable. Only muscovite mica with flakes and books of size about ($1' \times 1' \times \frac{1}{8}''$) are seen.

Feldspars for the ceramic industry.

Feldspars occur abundantly in the pegmatites and aplites of the Peninsular Gneissic Complex widely scattered throughout the area. These pegmatites, however, are generally fine-grained and few are coarse enough for the separation of the feldspars by hand-picking from the intimately associated quartz.

Numerous runs of pink and white pegmatites especially at the contact areas of the Dharwar rocks, are frequently met with, but they cannot always be considered as suitable for glass manufacture for the reasons mentioned above.

Below a few localities are given where pegmatites may be found in abundance. But as the best materials occur far in the interior of the hilly tracts transport is difficult and they are of little or no economic value.

(1) Red coarse pegmatite veins occur at the margin of the Dharwar schist in a *nala* south of Shahpur tank to the west of the main road to Yadgir. White varieties are also common. These pegmatites occur as patchy outcrops in the stream-bed and their extensions are obscured by the black cotton soil spreads.

(2) Pink and white pegmatites occur east of the main road to Gugi about a mile from Shahpur, in a *nala*.

(3) A large number of white coarse pegmatite veins run along the margin of the Manglur belt from south of Nagnur on the Nagnur-Karadhalli track.

(4) Coarse hornblende pegmatites with occasional blue quartz and blue feldspars occur abundantly between Godrihal and Janipur.

(5) Red coarse pegmatites are abundantly met with at Kudligi in the *nala* bed north of the village.

(6) White coarse pegmatites are exposed in a *nala* one mile east of Madnur on the Madnur-Yedlapur track. The pegmatites here are also associated with calcareous decomposition products.

Materials for cement manufacture.

The possibility for utilising the limestones and shales of this area for cement manufacture may not be overlooked. Beds of limestone in the adjoining and contiguous areas beyond the southern limits of the area under report, are of a quality which appears to be suitable for cement-making, as they contain almost negligible quantities of iron and magnesia.

Salt.

The occurrences of brine and saline efflorescences in this area have been exhaustively dealt with in the Departmental Journal, where the Baichbal valley has been particularly referred to.* Salt is manufactured from both the brine wells as well as from saline efflorescences in the Baichbal valley.

In the eastern part of the area under report, there are also some sporadic patches of saline areas, particularly along *nala* zones, where salt is manufactured from saline earth only. For instance, the region to the south of the main road from Surapur to Yadgir is covered with a thick mantle of black cotton soil intersected by numerous *nalas* draining into the Kistna. Salt works were noted in many of the *nalas*.

The relation of these saline areas to the black cotton soil, pink pegmatites and Dharwars is similar to the other prominent saliferous zones in the Raichur Doab.

* Journal, Hyderabad Geological Survey Vol. II, Part 1: p. 139.

Building stones.

Both the gneissic and the sedimentary rocks of the area afford any quantity of building and road material.

The pink and grey varieties of the granitoid gneisses, particularly the finer uniform grained types, yield excellent material for heavy construction. These are widely dispersed throughout the country. The hills south west of Naikal are extensively quarried. The northerly slopes of the Shahpur hills have been quarried to meet the local demands; so also the Surapur granitoid hills have been extensively used. Reddish brown gneissic slabs of about $2\frac{1}{2}' \times 1\frac{1}{2}'$ are obtainable from the hills north of Bilaspur.

The brick-red syenites afford stones of decorative value.

(*a*) Veins of red syenite are exposed in the *nala* to the south of the Shahpur Tank. Epidote veins also occur, mottled with red feldspars.

(*b*) In the Kudligi and Yediapur *nala* many red syenite bands associated with epidote veins were noticed.

The numerous doleritic dykes and quartz reefs and Deccan Trap boulders may supply any quantity of road-making materials.

The Dharwar hornblende schists are ill-suited for heavy construction, yet slaty varieties of the schists and the hard trappoids may be found useful for ordinary light construction. The masses of hornblende trappoid schists are cleavable at Bonal and other localities between Bonal and Manglur.

The Bhima series of rocks are partly developed in the area under report towards the western part.

1. *Sandstones.*—About a mile west of Kachaknur on the Yedihalli track, feldspathic sandstone is quarried for building purposes. But generally these beds at the base of the Bhima formations in this area are not good in quality, being mostly impure and ferruginous.

2. *Shales.*—Shales are poorly developed, in laminated and friable beds hardly suited for building purposes.

3. *Limestones.*—The limestones are mostly grey in colour and occur both as massive beds and flaggy layers suitable for building and flooring. These are quarried in many places, as at the north-west of Yedihalli and south-east of Arikeri, where flagstones about 6″ in thickness are available and removed for local house construction. Finer varieties of flagstones below 2″ thick are available in thin layers to the west of Mudnur. Thin slabs about 1″ to 2″ thick are often found intercalated in the upper layers of the pink shaly beds.

Archæological finds.

Several well-shaped chipped limestone implements were picked up by Bruce Foote, lying with conglomerates a little to the west of Yadihalli and east of Arikeri. The finds were interesting as these implements were made of limestones and observed for the first time in South India, as hard siliceous limestones had been used here by prehistoric man in the absence of quartzite.

Two important sites of prehistoric interest were, however, discovered during the survey.

(1) On the track from Halisugur to Benkanhalli, near the north of the latter village, the last remnant of

an "Ash mound" was seen. The material has been freely quarried by the villagers to be used for white-washing their houses.

The mound is practically obliterated and is about 46 ft. long, 16 ft. wide and about 7 ft. high. It is composed of slaggy and scoriaceous calcareous material similar in texture and composition to those reported from Machnur, Gandur and a host of other places in the Raichur Doab. (*Vide* Plate X, photo 1).

(2) A very interesting site of a group of stone-alignments may be noted at Vibhutihalli about a furlong to the north of the village and about 100 yards to the east of the main road to Shahpur, on a plot of land about 300 yards square. A large number of boulders are seen which may be easily mistaken for some natural pink granitoid boulders lying imbedded in the ground. The stones are 3 to 4 feet in height, and as broad as they are high. But on closer examination their real character is revealed, as they are found to occur in parallel rows, the boulders lying at about 10 yards apart from each other. Some boulders lie singly and others in groups arranged in ellipses or circles. These stone-circles naturally indicate that the boulders with which they are composed must have been placed there by human hands. Many stone-circles are seen lying along these rows of single boulders.

From the large number of boulders crowded in one place, it is suggested that the group would mark the site of a prehistoric graveyard, and each of these boulders, the grave of a prehistoric man. Some excavation work may yield interesting results. (*Vide* Plate XI, photo 1).

III. GEOLOGY OF PARTS OF MAHBUBNAGAR AND GULBARGA DISTRICTS.

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Introduction

After the completion of the survey of the Raichur Doab, the attention of the Department was directed to the geology of the area north of the Kistna river, *i.e.*, Mahbubnagar and Gulbarga Districts. In pursuance of this scheme, portions of Yadgir and Makhtal taluqs were taken up during the field season 1344 F. The survey in Mahbubnagar District was continued during 1345 F., when the remaining portion of Makhtal taluq, parts of Mahbubnagar taluq and Amarchinta Samasthan were completed. The following pages refer, therefore, to the work of two seasons and the relative portion of the accompanying map will show the geological features of the area.

Area. The area under report is included in the Survey of India map sheets Nos. 56 H/SE., 56 H/SW., 56 H/NW. and 56 H/NE., and consists of the major portion of Mahbubnagar and a small part of Gulbarga District.

The area consists of an irregular portion to the north and east of the Kistna-Bhima confluence, bounded on the south and west respectively by these two important rivers and on the north by Lat. 16° 35′, on the east by the Amarchinta Samasthan boundary, and a remaining major portion which lies to the north of Lat. 16° 30′, comprising a rectangular block bounded on the north by Lat. 16° 50′, on the east by Long. 78° and on the west by Long. 77° 30′. The total area thus covered is over 1,100 sq. miles.

Object. Though no geographical unit could be obtained for the area, yet it may be considered to form a geological unit comprising a part of the crystalline complex of

Hyderabad. The survey to the north of the Kistna was particularly taken up with a view to explore the continuation of the Dharwar bands of the Raichur Doab and their economic possibilities. Moreover, the area referred to above was absolutely unsurveyed and a systematic survey of the area was therefore long due, to fit in with the general scheme of the geological survey of the whole State.

Previous notice.

As has already been indicated, the country under report had not had any previous attention and no literature in the form of reports or traverse notes are available beyond some minor references to some mineral occurrences in certain parts of the district alluded to in the Imperial Gazetteer of the Hyderabad State. Bruce Foote, in his Memoir on the South Mahratta Country,* describes areas to the west and King in his Memoir † refers to the Purana rocks to the south of this district touching upon the fringing rocks to the north of the Kistna. Even the topographical maps of the southern parts of the district, like Amrabad, were not available till recently and the whole country has practically remained so far, a *terra in cognita* for the geologist.

Topography Hill-system

The area consists of a plain undulating country to the south with a few hills scattered here and there, pointing to long ages of denudation which has practically reduced this belt of country to a dissected plain traversed by numerous meandering ephemeral streams. The country to the north of the Kistna typically exhibits a sloping plain covered by black cotton soil and pebble-beds here and there. Further to the north, however, the country is rugged and hilly and the tract between Narayanpet and Mahbubnagar is particularly so, with rounded knobs and elongated ridges broken up by deep valleys covered

* G. S. I. Mem. Vol. XII
† G. S. I. Mem. Vol. VIII

with reserved forests. The headquarters of the district is situated just at the base of a group of hills composed of granitoid gneisses and dykes which make a conspicuous feature of the landscape breaking the monotony of the flat plains to the south. The highest hills rise to about 2,332 ft. above mean sea-level, most of the hilly country being above the 1,500 ft contour. The low level country is to the south, with an average elevation below the 1,200 ft contour. Plate VI, photo 4 shows the Hill Fort at Koilkonda, Mahbubnagar District, where the typical granitic weathering can be noted.

Rivers.

The general slope of the country is south and south-east and all the streams and *nullahs* flow either to the Kistna or to the Bhima. The Kistna flows west to east for some distance and then follows a south-east course beyond the limits of the survey. There are only a few perennial streams in the area, and the Magnur stream, the Pedda Vagu and the Musapet-Rasala stream may be mentioned as some of the important ones. All these have a southerly course and empty themselves into the Kistna. The average rainfall, which is about 34 inches, is much higher than that of the Raichur Doab, accounting for wide areas of thriving forest reserves in the district. The rainfall usually is distributed uniformly in the numerous ephemeral nalas, mostly running in the sandy area produced by the denudation for ages of the gneissic rocks. They gradually dry up with the approach of summer, giving sufficient time for the water to soak into the sandy plains, where the water-table is maintained at a comparatively high level of about 15-20 ft. below the ground-level, supporting an extensive wet cultivation in the country. As is characteristic in the Telingana districts, the area is studded with numerous tanks supporting local fields of wet cultivation, a pleasing contrast to the Raichur Doab. Study of well-logs of numerous wells has disclosed the nature and distribution of the underground water and a summer water-level survey of the area has brought out interesting features in the

oscillation of the water-table. A separate note on this subject forms an appendix to this report.

General Geology

By far the greatest portion of the country under report is represented by the Peninsular gneissic complex, in which elongated strips and small patches of isolated Dharwar schists and their epidioritic phases occur folded with the gneisses in a roughly NNW. trend. Quartz veins, pegmatites and granitoid gneisses often present a well-developed association with the epidioritic rocks. The country is traversed by a network of numerous doleritic and some dioritic dykes which run in parallel groups. One set of dykes have a general NW. direction and the other a NE. trend. These sets sometimes intersect each other.

Wide stretches of sandy tracts and brownish loamy soil occur throughout the area, while strips of black cotton soil are seen to the north of the Kistna as well as to the east of the Bhima confluence, where scattered patches of pebble-beds lie exposed at varied elevations of the alluvial country.

The main Dharwar belt in the area occupies a higher elevation than the surrounding gneissic country with which the Dharwars are folded. The smaller patches and shreds of these schists have been reduced to the base-level of the general cycle of erosion, in which the gneisses have been worn away with the residual Dharwar roof-pendants lying still entangled as denuded stumps. No difference in erosional level, therefore, between the gneisses and the smaller patches of schists is discernible.

The intermediate and higher elevations are invariably defined by the gneisses, which often occupy high hills. The present topographical configuration may be considered to be an expression of the original structural evolution of the gneissic complex, subsequently modified by peneplanation, local dyke activity and other regional

disturbances, resulting in the present differential denudation to which the country was subjected throughout geological times.

One is deeply impressed with the fact that there is no vestige of evidence to show any important oscillation of levels bringing about marine transgression or formation of land-locked lakes in the area under report, though the country along the Kistna and Bhima basins shows evidences of secular depressions in which the Purana series of sedimentaries were deposited. Long ages of denudation have weathered and removed the rocks of the gneissic area enormously and as a result of this, vast stretches of sandy tracts derived from gneissic rocks characterise large portions of the country, particularly to the south. Fringing, however, the banks of the Bhima and the Kistna and in the areas represented by the basic hornblendic gneisses and in the vicinity of Dharwars, strips of black cotton soil are formed, perhaps due partly to the weathering of the basic Archæan rocks and partly to the migration of soil from the Deccan Trap which occurs in great force to the north of the area.

Rock Systems

The rocks of the area may be divided under the following heads :—

v. Soils and alluvium.
iv. Pebble-beds.
iii. Doleritic and epidioritic dykes.
ii. Peninsular gneissic complex.
i. Dharwars with associated epidiorites and dioritic dykes.

Dharwars.

The Dharwar schists occur very sparingly in the area under report. Only a few elongated patches have been observed; the most important of them is about 12 miles long, with an average width of about half a mile, running in a NNW. direction from Narva in the south, through west of Patrachaid, crossing the main Hyderabad-Kistna

road near Jaklair and continuing in broken patches up to near Phulmamri in the north. This band may conveniently be termed the Jaklair-Narva band.

Another narrow elongated patch occurs north of Lingampally, crossing the Makhtal-Utkur, track covering an area of about 2 miles long and hardly a quarter of a mile broad. Towards the south-south-east, from near south of Rudrasamudram, very small elongated patches continue in the same trend in broken continuity reaching up to the Kistna near Angunda. The patches are so much eroded and broken up that their boundary can at best be only approximately delineated and only their alignment is of interest. Five such mappable patches are indicated on the map south-south-east of Makhtal. All along the trend of these schist patches, the area is particularly studded with salt works. In this connection the saline zones along the Raicod stream, as well as along the east Panchligal and Kadmur *nullahs*, are worth notice. The northern continuity of the Jaklair-Narva band is highly broken up and only vestigial schist patches south-east of Utkur mark the apparent continuity of the band towards the north and its further extension north-north-west is represented by a schist outcrop below the Pagdimari tank *bund* just beyond the limits of the area under report.

Other very minor patches occur here and there scattered throughout this belt but too small and shredded to be indicated on the map, so much so, even the indication of its original general orientation is obliterated, though their presence is helpful to suggest the probable extent of the Dharwars now almost totally denuded away.

It may be observed that these disconnected strips and patches of Dharwars indicate the northern continuity, beyond the Kistna, of the regular bands which occur in great force in the Raichur Doab. The Jaklair-Narva band is apparently the northern continuation of the

Gadwal schist band of the Raichur Doab, as is evidenced by its persistency in trend with the main band to the south of the Kistna. The survey of the southern parts of Amarchinta is awaited with interest,* as this Samasthan may disclose a genetic continuity within the wide areas separating the trend of the two bands, namely, the Gadwal and the Jaklair bands.

These Dharwar belts are mostly covered with black cotton soil which occupies the adjoining slopes and valleys, obscuring the contact of the schists with the gneisses, and the presence of such soils is very often suggestive of the probable extent of the Dharwars. The occurrence of saline areas and salt works also helps to some extent to suggest the probable existence and extent of the Dharwars in their vicinity. But in spite of these features, the delineation of the actual boundary of the Dharwars can only be very approximate in view of their discontinuous, scattered and broken-up character. So the mapping can at best emphasise the continuity, trend, and mode of occurrence of these oldest rocks. Another peculiar feature in the vicinity of the Dharwar patches is the occurrence of wide-spread broken quartz and binary gneisses which, as elsewhere in the Dharwarian country, are suggestive of an intimate structural association with the Dharwars. The occurrence of such quartz spreads with little or no Dharwars have often been indicative of the original extent of the Dharwars which have been subsequently denuded away, leaving the pegmatites and quartz in a highly broken condition.

Jaklair-narva band.

This band consists of fine to medium-grained type hornblende schists traversed by quartz veins and dykes. They are typically foliated and schistose with a north-north-west strike with steeply inclined dips. This band forms

* The survey of Amarchinta Samasthan during 1346-F. (1936-37 A.D.) season has revealed a long but narrow band of Dharwars connecting up the Gadwal band with the Jaklair-Nurva band.

a ridge and the cart-track between Mantangoḍ and Patrachaid exposes a typical section of it. The quartz veins are few, rarely bluish, but mostly white and non-auriferous.

Linga.mpalli patch.

This patch is constituted similarly to the Jaklair-Narva band except that the southern portion of the band is highly foliated schists, mostly chloritised. This band is also particularly characterised by the occurrence of saline zones and saline efflorescences along the *nullahs* which cut across the band.

The small patches forming its southern continuity south-south-east of Makhtal, consist of highly altered representatives of the hornblende schists where the rocks have undergone thorough recrystallisation developing hybrid types.

The southernmost patches near Angunda are particularly characterised by acidic intrusives which pass as ramifying branches into them. There are evidences of wide assimilation and recrystallisation developing all varieties from coarse hornblende rock, consisting mostly of large crystals of hornblende, through intermediate stages of mottled types to finer varieties where the assimilated acidic material mostly predominates.

The Budpur-Kadmur track south of Kottapalli, exposes soft talc-chlorite schist, soapy to the touch. These occur only as minor weathered patches.

Just south of Kottapalli there is a run of dyke-like, bouldery, hard, ribbed, basic, gray hornblende rock trending roughly north and south. The rock is an assimilated hard hybrid variety with which spotted hornblendic types are also developed. The exposure in some places is much intruded by hard acidic veinlets which on weathering has given rise to a ribbed appearance.

A hard and highly assimilated hornblendic rock occupies the ridge just west of Narva and in fact touches the south-west corner of the village. The close and intimate association of pegmatites and quartz veins with this dioritic rock is of interest. The northern continuation of the exposure, forming the ridge .1205, is entirely composed of quartz reef and pegmatitic veins. It is thus clear that these rocks in their southern continuation have assimilated hornblendic rocks giving rise to the dioritic ridge west of Narva referred to above. A further southern continuation of this dioritic rock is well exposed at the north end of the Yamki tank bund. It is to be particularly noted here that the broken up Yamki end of the Jaklair-Narva band of Dharwars occurs very close to the assimilated dioritic exposure of the Yamki tank, and it is very likely that a wide assimilation has taken place.

Some interesting basic rocks of probable Dharwar affinity may be mentioned here in this connection with interest. South of Apreddipalli and near Narayanpet are noted some dyke-like exposures in ridges and isolated knobs, consisting of extremely metamorphic basic rocks with numerous injections of quartz veins and pegmatites in them. These rocks invariably have a linear disposition and appear as dykes, with patches and stringers of acidic gneisses, especially quartz and pegmatites, entangled in them. With progressive contact effects, different stages of crystallisation have been produced in the rocks, in which types varying from highly basic coarse hornblendic rocks to fine-grained acidic masses may be distinguished.

Greenish black and white mottled varieties are common where the acidic material has been broken up, partly assimilated, and partly engulfed in the invaded basic rocks.

Some of these dyke-like masses run from a few furlongs to more than 2 to 3 miles in length, occurring

in practically unbroken persistency. Some of these major dykes appear to end in knob-like hills in their trend and then abruptly terminate. A typical example is furnished in the hill about a mile north-east of Narayanpet, on the Perapalli track. The best exposure of such assimilated dioritic rocks is in Narayanpet, forming the ridge on which the travellers' bungalow is situated and also on the track between Narayanpet and Jajapur, about a mile west of the latter village.

A field relation between these dykes and the doleritic dykes is furnished in the hill .1713 west of Singaram, where the dolerite dyke appears to cut an older diorite dyke. It is interesting to note that these hornblendic dykes near Narayanpet follow the trend of the Jaklair band of schists and may well be regarded as representing the continuation of the band to the north-west near Narayanpet and beyond. Most of these dykes also show a distinct north-north-west orientation. This, perhaps, suggests a Dharwarian affinity as hornblendic dyke phases of the type Dharwars further south. As has been noted in the Dharwars of the Raichur Doab, particularly in the Maski inlier zone, such dyke-like residual masses of the Dharwars are a very common feature. In areas where most of the schists of the main belt have been denuded away, hardened masses occur as vestiges, which show with great force the intrusive relation of the gneisses against the schists at the contact. Some interesting occurrences of quartz veins of Dharwar age may be mentioned here. Near Mandipalli a ridge of greenish, pink and white mottled quartz vein occurs, with stringers of micaceous hæmatite. The whole ridge is about half a mile long and about a furlong or two broad and ends as abruptly as it begins. Its strike is a few degrees north of west and the quartzite is traversed by white quartz veins, at the contact of which specular hæmatite is developed. The hill assumes a reddish brown appearance and the flanks are covered by brownish earthy

debris which obscures its relation with the surrounding country. In the cultivated fields, to the south of the hill, and west of Mandipalli, rock fragments are met with which when broken expose shining sheaths of specular hæmatite. This is the only occurrence of its kind in the area and is lithologically comparable to the earliest acidic members, more intimately connected with the Dharwar basics than to the associated members of the Peninsular complex. The quartzite sometimes assumes a greenish colour which may be due to the local assimilation of some basic material now totally untraceable in the soil-covered area in the near vicinity of the ridge. There are, however, prominent dykes running in the neighbourhood to the south-east and north of this occurrence.

It may be noted here that similar occurrences of pink and white mottled quartzites in association with diabasic dykes, with typical mineralisation of calcite and specular hæmatite, have been noted in Koratgi, Machnur and Chincholi in the Raichur Doab and Tintini in Surapur taluq where in addition, indications of copper in the form of chalcopyrite, cuprite and as basic carbonates have been noted. Similar quartzitic rocks with copper ores have also been noted in the area under report. Such occurrences near the margin of the Jaklair-Narva Dharwar band south of Ramasamudram, and near a schist patch on the Karni-Kalwal track, may be mentioned here.

Petrology.

The Dharwar schist members of the area are very similar to those already described in the Raichur Doab.* The hornblendic schist is very often altered into recrystallised varieties or epidioritic types, due to the numerous intrusions of the acidic gneisses in them. Some of the gneisses adjoining such schist members have become highly hornblendic. Various stages of rock types from

* Jour. H. G. S. Vol. II, Part. i Vol. III Part. i.

hornblendic gneiss through epidioritic types to coarse recrystallised hornblendic rocks have been developed.

The type hornblendic schists (K 5/44 & K 112/44) mostly consist of hornblende with characteristic pleochroism. It sometimes occurs with frayed edges, and in torn shreds. Cloudy plagioclase felspars, apatite, sphene and some free quartz are also present. In some sections schistosity is also clearly marked; when the hornblendic plates crowd into patches (as in K 55/44) they give a mottled appearance to the rock.

The epidioritic type (K 50/44) consists of hornblende with frayed edges and in torn up shreds, but more often in fresh crystalline outline. Sometimes the hornblende is seen altering into biotite. Plagioclase felspars are in abundance, often cloudy and altered into epidote. Apatite, sphene, ilmenite and rarely pyrite also occur. The hornblende sometimes yields perfect basal sections with typical cleavage lines. In one of the sections (K 22/44), apatite grains were noted, with typical hexagonal outline. Quartz is invariably present.

The recrystallised hornblende schists develop large hornblende crystals interlocking with each other with little or no interstitial material. The fine-grained varieties, K 6/44 and K 3/45, have smaller crystals of hornblende with greater preponderance of quartz and felspars, probably derived from the assimilation of the acidic injection in them.

The granulitic types (K 53/44) consist of stunted prisms of hornblende more or less rounded at the edges, dark green, and non-pleochroic. Some show alteration into biotite. Quartz and felspars are present in grains, the whole rock presenting a granulitic texture.

The quartzites at Mandipalli (K 114/44 & 114b/44) consist of highly crushed quartz with large pieces showing strained shadows. The quartzitic material is much impregnated with hæmatite, both as grains and in the form of dust.

Peninsular gneissic complex

As has been already stated, the major portion of the area under report is represented by the Peninsular gneissic complex. In the study of the Peninsular complex of the Raichur Doab, they have been divided into two main groups, *viz.*, the Grey and the Pink series, each having its own sets of pegmatites, aplites and quartz veins. This broad classification holds in the area under review. Without going into the details of this classification, which is incorporated in the previous publications of the department, a brief summary of the main types of the complex may here be described with reference to their relative distribution. One striking feature of the Peninsular complex of the area consists in the abundance of the more acidic representatives in the form of aplites, pegmatites and quartz reefs and veins which occur in great force throughout the area, particularly in the southern portions, where their extensive weathering has given rise to vast accumulations of sandy plains. It is also noteworthy in the areas east, south and north of Makhtal, where the pink acidic rocks and sandy soil predominate, that most of the Dharwars of the area are associated with numerous salt works in their vicinity. This peculiar association of salinity with the pink acidic members in the vicinity of Dharwars is a marked feature in the Raichur Doab also.

The grey series of gneisses are mostly developed in the hilly tracts of the north, where they are often associated with the pink members. No hard and fast line of separation regionally can be drawn between these two main series of rocks as one merges into the other imperceptibly, though intrusions of the pink series into the grey in the form of pink pegmatites are not uncommon.

Interesting types of basic hornblendic dark grey gneisses have been developed near Kistna-Hindupur, round about Konsi, and south of Khanapur near the salt works, particularly in the south-west corner of the area marked by the Kistna-Bhima confluence. The rocks

are hard, grey, hornblendic gneisses with epidioritic affinity, sometimes exhibiting ribbed weathering. Such rocks are also met with in the vicinity of the Dharwars where the members of the grey gneissic series form the country rock. It appears that such basic types have been developed due to assimilation of the Dharwars with the intruding gneissic rocks. Plate VI, photo-3, shows a porphyritic granite exposure with big erosion hollows caused by the weathering and falling off of basic xenoliths.

Pegmatites & quartz veins.

No attempt has been made to map all the pegmatites and quartz reefs in the area, but the most prominent quartz reefs with the associated pegmatites have been indicated on the map. The Gunmukla reef, Kodur-Lachampalli reef, Musapet-Shakapur-Udakatla reef, Koilkonda reef, the Kongatpalli and Vepur reefs are the most important and the prominent ones. The Vepur and Kongatpalli reefs continue much beyond the area under report and form only a portion of a huge system of reefs. Sometimes such reefs favour the accumulation of water and form sheltered areas favourable for tank sites. Advantage may sometimes be taken of the quartz ridges to form tank *bunds*. The Kongatpalli tank is a typical example of such a topographical feature.

As already stated, there are huge spreads of pegmatite debris in the vicinity of Dharwars. The huge sandy plains of Kistna-Magnur-Makhtal area testify to the spread and extent of these rocks which have been mostly responsible for the sandy soil of these parts. The pegmatitic runs have not been specially marked on the map, but have been included under one colour representing the Peninsular complex. However, specific examples, notable for their good felspars, have been noted and will be discussed under economics.

Petrology.

The area is particularly characterised by the abundant development of the more acidic types, consisting almost exclusively of quartz and felspar. A brief reference to some of the types is given below.

The junction zones of grey gneisses with hornblendic rocks are often marked by grey hornblende gneiss, such as that at Khanapur, in which hornblende occurs prominently.

The normal light grey gneiss (K 1/44) is mostly biotitic consisting of quartz, orthoclase and microcline, biotite, apatite, sphene and sometimes pyrites. K 15/44 shows some biotite derived from hornblende, and plagioclase felspars with typical multiple twinning. K 27/44 contains both hornblende, brownish mica and magnetite. Some hornblende gneissic types like (K 160/44) are associated with calcite.

The pink members are characterised by the presence of pink felspar and quartz. Epidote is of common occurrence and garnet (K 130/44) is sometimes developed.

Dykes.

As the map will show, the country is literally riddled with dykes. Comparatively speaking the dykes become more numerous as we approach the northern hilly area. They are for the most part dolerite dykes, medium to fine-grained; some are also porphyritic.

The dykes may be divided into two main groups according to their directional disposition.

1. The north-east dykes, and
2. The north-west dykes.

Though the above directions are the main trends of the dykes, yet, rarely, some prominent dykes such as the Kishtapur-Kondapur dyke strike roughly north and south. The east to west dykes, as the Abhangapur-Jamalpur dyke, are equally rare. The general run of the two main systems of dykes, suggests a possible directional weakness in the gneissic country through which the dykes found their way. The crowding of dykes in the hilly tract between Narayanpet and Mahbubnagar is particularly noticeable.

The dykes are everywhere found intrusive into the gneisses and are clearly of post-peninsular gneissic age. They are very similar to the dolerite dykes marked elsewhere as Cuddpah dykes. But in the absence of Cuddapahs or their equivalents in the area under consideration to show their mutual relation, one has no definite evidence other than that the dykes are of post-gneissic age. Plate VIII, photo 3 shows a narrow dolerite dyke cutting hill. 1,555 near the 91/4 miles stone on Hyderabad-Kistna road

The north-south dyke running east of Dupatgattu, past the deserted village of Ramampalli and west of Anjmur and further south cutting the hills .2099 and .1972, has been traced for a distance of nearly 10 miles. This dyke is very hard and dark in colour. It is an amphibolitic dyke and though in its course it crosses three typical dolerite dykes, the actual relation between them could not be definitely observed as each of the crossings were covered by boulders of both the dykes.

To the west of Rakonda hill .1566, is a dyke with caught-up angular inclusions of gneissic and quartz xenoliths. This dyke strikes north-north-east, crosses the Peddavagu stream and runs up to north of Baswapur, till the Baswapur-Pedda Rajmur track, and then its further continuation is lost.

Similar occurrences of xenolithic dykes are noted near Puridpur. The dyke appears nearly east of Puridpur, crossing the Mochintla track. It strikes southwards where, about a mile south-south-east of Puridpur, it bifurcates. The western branch is traced, crossing the Chitanur stream, *viz.*, Sitarampeta and Danganapuram and is seen to extend beyond the limits of the area further to the south. The other, eastern branch has been traced, running almost parallel to the former, and extends further south.

Both the Rakonda and Puridpur xenolithic dykes show inclusions of pegmatitic, quartz and rarely gneissic material, mostly angular, though occasionally the edges

and corners are rounded due, perhaps, to fusion. It appears that the country rock along the dyke was broken up and this broken material was engulfed in the intruding dyke. The Puridpur dyke, at its north end, has practically no xenoliths. Similarly the eastern branch of the Puridpur xenolithic dyke has sent veins into the adjacent gneissic country and has become chilled, hard, dark and very fine-grained and almost trappoid in texture. One other peculiar feature is that the xenolithic character is more pronounced in the middle of the dyke than towards the flanks.

One of the most important porphyritic dolerite dyke is traced for nearly 25 miles from near Alampalli in the west, crossing the main Kistna-Hyderabad road and proceeding eastwards *via*, Pagadabanda, Sattiwaram, Gajarandoddi, and striking east-south-east, south of Gopalpur, past Mushtipalli, to south of Iraldinne on the north Kistna bank. This dyke is highly porphyritic, with well-developed crystals of white plagioclastic feldspars. Another minor porphyritic dyke was noted crossing the Ajalapur-Malkapur forest track, about two miles north-north-east of Ajalapur.

The doleritic dykes have in many instances altered to greenish epidiorites, in which the augites are found changing into greenish hornblende.

The dioritic type of dykes of Dharwarian age have already been referred to under Dharwars.

Petrology.

The dolerite dykes are mostly medium to fine-grained, but occasionally porphyritic. They essentially consist of plagioclase felspars with augite. Ophitic structure is common, particularly in the porphyritic varieties. K 9/44 & K 48/45 present typical porphyritic structure, with augite altering into greenish hornblende, the leached-out iron ore occupying its cleavage cracks. K 82/44 and K 91/44 are typical epidiorites. The augite is mostly changed into hornblende, leaving the unaltered core.

Pebble-beds.

Interesting occurrences of pebble-beds are met with in several places, mostly confined to a zone of about two miles to the north of the Kistna river. A widespread occurrence is noted between Gurjihal and Thangedi over an area of about a mile and a half in length and about half a mile broad. The actual boundary of these pebble-beds, however, is rather difficult to determine on account of a heavy overburden of black cotton soil. They consist mostly of cherts, quartz, chalcedony, and gneissic fragments varying from about 1″ to 6″ in diameter. They are sub-angular, indicating very little water action. In the river section they rest on the gneisses, cemented with calcareous matter and silica and pass towards the surface into finer gravels buried under the black cotton soil.

Similar pebble-beds of importance are found to the south of Hindupur in defined patches, one of them occurring along the Kistna-Hindupur road and the other, a larger one, along the Kistna-Gudabelur road. The section *in situ* was not seen and they lie scattered on the black cotton soil of the area.

Other similar exposures are found to the south of Gudabelur and in broken patches along the Kistna bank eastwards up to Mudumala.

Similar occurrences were seen along the east bank of the Bhima from near its confluence with the Kistna, up to the south of Belgundi in the north, sparingly distributed in the intervening country. North of Govindhadgi these pebble-beds occur in great force all along the track from Kondapur to Govindhadgi and Govindhadgi to Bhimanhalli and for some distance along the Govindhadgi-Munigal track. The pebble-bed here is particularly characterised by smaller pebbles of chalcedony, jasper, wood opal, agate and other kinds of hydrated silica suggesting their source from Deccan Trap country further north.

Rare occurrences of pebble-beds were noted to the east of Kottapalle △1568 on the track from Magnur to Kottapalli. The pebbles are mostly cherty, quartzose and sub-angular, most probably local. It must be mentioned that they do not much resemble the pebbles of the Kistna and Bhima basin.

The occurrence of these pebble-beds raises some consideration as to their source. The Bhima series of rocks, particularly the basal conglomerate beds, as well as the chert beds of the Deccan Traps are too far away to suggest their direct derivation from this source.

The most probable explanations seems to be, in the absence of oscillation of levels in this part of the gneissic country, that these beds must have been deposited as high flood accumulations of the Kistna and the Bhima. The highest levels at which they are now found are not of such magnitude as to preclude the possibility of their being deposited in times past when the Kistna was in high floods. The consideration of the country through which the Kistna then flowed must have some relation with their deposition.

As already suggested by Bruce Foote, there can be little doubt that the Kistna should have been affected by causes not now in action, by which, its waters were raised to heights vastly exceeding the highest flood-level now obtained. Very probably the existence of barriers along the course of the Kistna must have dammed back the flood waters to greater heights than their present maximum levels. This explanation is perhaps more probable than to assume a disturbance affecting a general depression of this part of the country during the late geological times.

The Deccan Trap rocks are nearly 30 miles away from the pebble-bed area. These beds may also be considered to be the relics of the past river terraces of the Kistna when it had not cut down its bed to the present level.

These high level gravels should not be confused with those formed by the present floods, and may be regarded as an older alluvium.

Recent alluvium and soil.

The only two prominent rivers bordering the area are the Kistna and the Bhima. The north bank of the Kistna and the east bank of the Bhima are particularly characterised by a thick deposit of black cotton soil carried and shifted by numerous streams which traverse the country. They generally form terraces along the banks. Shingle beds, loamy soils, and sandy layers generally alternate in the river sections.

Sandy loams are carried by streams during the rains, forming silt beds along the banks of the smaller streams. In saline zones they are associated with secondary calcareous deposits. Along low grounds and marshy palm-covered areas, the loamy earth is characterised by a saline efflorescent product which gives rise to dhobie's earth, and other salts.

Soils.

The soils of the area may be considered mainly under the following heads :—

1. Black cotton soil.
2. Calcareous loam.
3. Red loamy soil.
4. Sandy gneissic soil.

Black cotton soil.

This soil is confined to the river banks and along the Dharwar zones. The grey highly hornblendic gneisses of the Kistna Railway Station, Hindupur, Chegunta, and Konsi areas are covered by a thick mantle of black cotton soil. The thickness is variable and from the well sections it appears to be on an average 4–5 ft. in depth. In the river bank and lower grounds, however, it is much thicker, about 10–15 ft.

In river sections it is found to be intercalated with arenaceous and calcareous layers. When dry, after cultivation, it has numerous mud cracks which let air into the lower layers. It forms extensive undulating tracts of treeless country intersected by numerous water-courses, which flow only in the rainy season, when a large quantity of black cotton soil is transferred to lower levels. This annual erosion removes the soil, exposing particularly the lower levels, leaving behind a calcareous loam which hardens into an impervious layer, rendering the country barren, unless an effective scheme of field bunding is introduced on a large scale in the black cotton soil area. Otherwise the country will eventually be depleted of its rich soil and impoverish its agriculture, exposing it to famine conditions.

Red loamy soil.

In gneissic areas, where the ferro-magnesian constituents predominate and where numerous dykes traverse the country, disintegration and decomposition of these rocks often give rise to red loamy soil. Such areas are not always extensive but are limited to zones of their parent rocks. They pass from gritty calcareous *moorum* to finer loamy soil, impregnated with ferruginous matter, organic decomposition products often adding to their fertility. Unlike black cotton soil, this loamy soil allows good drainage.

The gneissic soil.

This is by far the most extensive soil in the area under report. The disintegration of gneiss, pegmatite, aplite and quartz veins has given rise to vast spreads of sandy soil which support only a scanty vegetation and where agriculture is very much handicapped. In such areas it has been noted that the *ryots* mix sandy soil with black cotton soil and manure or silt from tanks, so to bring the sandy soil under cultivation. Extensive spreads of such sandy areas lie fallow. The powerful summer winds and storms shift the sands from place

o place accumulating them in some places into undulating dunes, only to be shifted during the subsequent seasons.

Fresh attempts are being made by the villagers to arrest this migration, by planting rows of trees, particularly "sendh," which shelters the protected area from blown sand. These trees are planted on the windward side of the fields. Sometimes the plot of land is fenced on all sides to ensure greater protection.

Under the action of disintegration and decomposition the normal gneisses give rise to the usual soil, which may be termed sandy loam. Unlike the sandy soil as above, these soils are more fertile, being rich in clay, potash, and other constituents favourable for plant growth. In a normal gneissic country such a soil is extensively developed and it is found mostly suitable for garden crops and for wet cultivation. In the absence of tanks, numerous small areas of wet cultivation are supported by well irrigation. The general water-level of such soil-covered country is comparatively high and the sinking of *moht* wells is not expensive and hence generally resorted to.

Economics. Building Stones.

The varied pink and grey granitoid gneisses of the area can supply any quantity of suitable building material. The hilly tracts in the northern portion of the area is particularly rich in such building stones.

The porphyritic varieties of granitic rocks are particularly suited for decorative construction.

There are many local quarries which produce ordinary dressed stones, slabs and pillars for heavy construction.

The numerous dykes and quartz reefs yield good material for road construction.

Salt.

Brine and saline efflorescence occur in many parts of the area, mostly limited to the south and west. They are very rare in the northern hilly parts. The saliferous zones are widely distributed in the black cotton soil area especially along nalas, particularly in the vicinity of Dharwar patches. It is not necessary to go into the origin and nature of distribution of this saline material as they have been dealt with in the previous Journals* of the Department.

There are numerous salt works distributed in the area under report; very many are active and some are abandoned. The sites of active and abandoned salt works have been noted.

Both edible and tannery salts are produced. Broadly speaking, edible salts are produced where there is good brine for lixiviating saline efflorescence. Tanning salts are produced where inferior quality of saline earth is lixiviated with ordinary water. It appears that the quantity of edible salt produced is subordinate to the amount of impure tanning salt recovered. The usual method of manufacture of salt as is common in the Raichur Doab, is resorted to in these parts also. Saline efflorescent earth is collected or artificial efflorescence is produced by sprinkling brine on made ground. This is collected and lixiviated with brine or ordinary water. The resulting "chara" is allowed to evaporate in pans by solar evaporation, and the salt collected.

In some places like Jinral, Dokur, Venkataipalli, and Kotakadra, the pot method of manufacture, which is only a modified form of the usual process, is employed. As this method has not been described in the previous publications, it is briefly described here. In this process,

* Jour. H. G. S. Vol. II, Part i, pp. 137-178.
" " Vol. III, Part i, pp. 85-90.

the lixiviation is not effected in the specially made earthen lixiviating units, but only earthen pots are used. A medium sized earthen pot is taken. A big hole is made in its bottom, and is covered from inside by a piece of cloth or beaten twig. Saline earth is put into this and water added and stirred. This is placed on a big earthen pot into which the saline solution trickles. When the saline earth in the upper pot is exhausted, it is thrown out and a fresh charge added. Thus a battery of pots are used and the "chara" thus collected is evaporated. No special evaporating pans are constructed. A rocky top or a freshly quarried flat rock surface is chosen and small 'kattas' are made by imbedding small stones or broken pieces of pottery in mortar all round the enclosures so to form a rim, which can hold the saline solution. In summer, the rock base gets heated and evaporation is thus aided and the salt crops are collected. This modified process is used where brine is not available and even the saline efflorescence is not largely found. This is a simplified process where no elaborate expensive construction is necessary and is carried on mostly by womenfolk of the poorer class.

"Shora" or potassium and sodium nitrate is manufactured from the saline earth scraped from below village refuse heaps. This was being made at Gudabelur, Makhtal, and Kadichur in Yadgir taluq. It is not worked every year, but at intervals of 4–6 years. The small quantities it produces are used locally for making fireworks and gunpowder.

"Khar Neemak" or soda earth is found extensively, as a white encrustation which is light and powdery. This consists essentially of sodium sulphate with some sodium carbonate. Such occurrences are very common in parts of Makhtal taluq near Satyawaram, Khanapur, Kadmur, Raicod, Mantangod and Sodampalli. They were also noted in parts of Yadgir taluq.

This was collected and treated for the manufacture of soda-ash which was extensively used in the glass works at Manikonda and Gazulpet. The sites of soda-ash manufacture are shown on the map but they are now abandoned as there is no demand since the ancient glass-making industry declined.

The process of making soda-ash from saline efflorescence is detailed under glass-making, below.

Ancient glass-making industry.*

A number of old glass-smelting furnaces were noted in Manikonda, locally called Gazulu Manikonda, Gazulpet and Ramachandrapur in Mahbubnagar District. "Gazulu" in Telugu means glass bangles, and probably the villages have been so named from time immemorial after this ancient industry.

There are even now about 30-40 old furnaces in ruins at Gazulpet, about 60-70 at Manikonda and about four at Ramachandrapur. This clearly testifies to the once flourishing glass-smelting and bangle-making industry in these parts. It is stated that hardly two decades ago the industry was in active operation and that these villages were, in times past, the centre of an active glass and bangle-making industry whence the State drew its main supply. Almost every family in the villages was engaged in this work when it was at its zenith of activity.

The old families who worked this industry are mostly dead or have taken to other vocations. Some of the scions of these old families are still found occasionally engaged in this industry struggling to keep up their old tradition. Even with such operations carried on at long intervals, they cannot find a ready sale for the finished products, which hardly pay them.

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* "Ancient Glass-Making Industry in Parts of Mahbubnagar District, Hyderabad State." Paper read before the Indian Science Congress Sessions, 1937: by L. S. Krishnamurthy.

Raw materials for smelting glass.

Quartz and soda are the two main raw materials used for this industry. The fine white quartz reefs supply any amount of silica. There are quartz reefs very close to both the villages—Manikonda and Gazulpet. The quartz reef near manikonda is highly disintegrated and can be easily powdered. Quartz is broken up into small pieces and then powdered in big grinding stones by hand labour. The powdered material is sieved and the resulting fine quartz flour is ready for smelting.

Soda.

Good quantities of saline efflorescence and soda earth or "Khar Neemuck" occur in parts of Mukhtal taluq. Satyawaram, Khanapur, Kadmur, Raicod, Mantangod and Sodampalli are some of the localities where soda earth occurs extensively which was used for the manufacture of soda-ash, to supply the glass works at Manikonda and Gazulpet. Soda-ash was also made near Gazulpet which could not meet the whole demand and so most of the supply had to be imported from outside localities mentioned above.

Method of making soda-ash.

The efflorescent soda earth along with sand and mud is collected and stacked. A sump is made in the ground near the stack into which this soda earth is put and water added. It is well mixed and kept constantly stirred. The liquid is transferred to another sump nearby, where it is allowed to settle. By the side of the second sump, a pan is constructed in the ground into which cow-dung is put and well mixed with the clear soda earth solution. A third sump is made, into which the cow-dung solution as well as the soda earth solution are put and well mixed. A drain connects this sump with two other sumps, one below the other, in such a way that in the last sump a clear combined solution is collected. A bed of straw about 1 ft. thick is spread on a specially made ground.

The combined solution is sprinkled on the straw layer and is allowed to dry. This process is repeated daily for about two months until a thick white layer of straw cake is formed. This is broken up, heaped and burnt. The resulting scoriaceous dirty ash-coloured material is the soda-ash used in glass-smelting.

Colouring materials.

Glass is made mainly of two colours, *viz.* (1) dirty dark greenish and (2) clear green. The blue and yellow varieties are very rarely made, but are mostly imported from Ferozabad. Copper sheets are burnt and the resulting oxide is added to get the clear green colour. The dirty dark greenish coloured glass, which is by far the most common variety of glass manufactured, is obtained by sprinkling cow-dung water on the charge and allowing the soot to collect in the surface. This is done by closing the aperture at the top of the furnace during the final stages of smelting. The proportion of cow-dung solution and soot is regulated so to give the required shade of colour and density. Cobalt salts are used to get the blue colour.

Furnace.

Great care and pains are taken in the construction of the special furnace required for smelting glass. The furnace (see Plate VIII, Photo 4) is about 20′ high, dome-shaped. The lower portion of the furnace is cylindrical, about $7\frac{1}{2}'$ in diam. and 6′ high, which forms the hearth. The cylindrical structure at its top bulges into a dome-shaped furnace forming a ledge $2\frac{1}{2}'$ broad all round. The dome has a diam. of $7\frac{1}{2}'$ at its lower end which gradually bulges to the maximum size of $12\frac{1}{2}'$ in diam. at its centre, to narrow upwards again into a small opening $1\frac{1}{2}'$ in diam. at the top. The wall of the furnace is made up of three layers. (1) The innermost consisting of fireproof brick lining 1′ thick (2) the next outer layer consisting of a covering of mud plaster 3′ thick at the bottom gradually thinning to about a foot or even less towards the top

(3) the outermost covering consisting of stone-work, with rubble between this and the mud layer. There is an opening at the lower end of the cylindrical portion of the furnace, which is blocked by a mud wall when the furnace is fully charged and ignited.

Charge

Strong and well baked earthen pots tapering towards the base are specially made to receive the charge of raw materials. About 18 seers of soda and 4 to 5 seers of powdered silica are well mixed to constitute a unit charge for each pot. Each pot when fully charged yields about 1 maund (12 seers) of glass, the extra flux forming a white cake on the top of the molten glass. The fuel used is ordinary firewood. A normal furnace of the above-mentioned size will take a charge of 200 pots arranged in tiers in a slanting position one over the other, the bottom-most row resting on the ledge of the furnace. (Plate II shows the construction and mode of arrangement of the charge in the furnace).

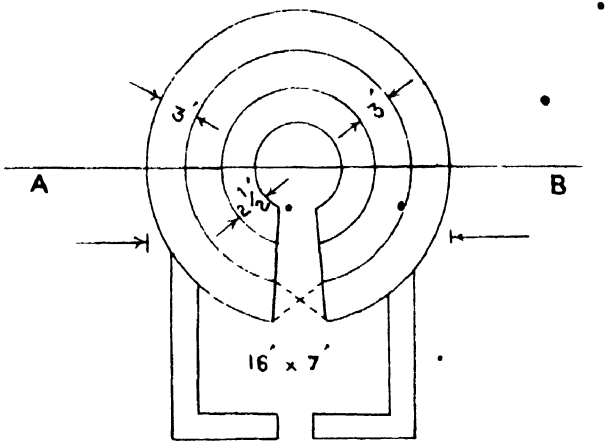
The furnace when fully charged is kept burning for three days and nights, and on the fourth morning a small sample is examined and if required, a further burning of 12 hours is continued. The furnace is then allowed to cool, which generally takes about a fortnight. The mud wall closing the opening at the bottom of the furnace is removed and the pots are taken out. The white scum at the top of each pot is separated and the pot is broken to get the glass inside; thus all of the 200 pots are broken one after another and the glass collected. The lumps of glass thus manufactured are used in making glass bangles. The white cake is not used again for smelting but is sold to leather merchants for curing raw hides.

Bangles-making.

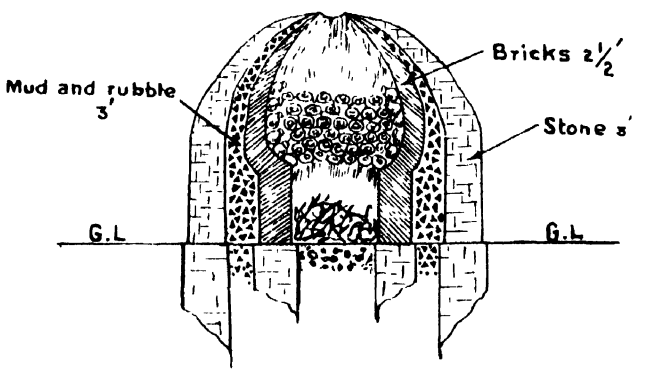
Glass bangles of various sizes and thickness are made by dexterous hand labour of skilled workmen. For this purpose a small furnace with a dome-shaped chimney is

PLATE. II.

PLAN
AND SECTION OF GLASS SMELTING FURNACE
Scale 1 inch = 16 Ft



SECTION ON (A-B)



made. The furnace is ignited from below. A ledge runs inside all round the base of the dome. There are 6–12 openings according to the number of workmen engaged, just above the level of the ledge all round the dome. Against each opening, resting on the ledge, is a wide earthen pot in which glass is kept in a molten condition. In front of every opening sits a workman, who with simple tools turns out thousands of bangles by skilful manipulation. The molten glass is taken as a big button at the sharp end of a long iron rod 1½" in diam. and worked up with dexterity with an iron spatula into a drawn-out ring. This red-hot crude ring is transferred on to a revolving conical earthen mould where it is worked into a round bangle of the required size and thickness.

The glass-smelting and bangle-making industry is now being carried on in a very struggling state and is almost dying. This crude method of manufacture is unable to compete with the modern market. The influx of cheap foreign material in fanciful designs has swamped the market and given a death blow to this once famous ancient cottage industry.

The only salvation to this dying cottage industry lies in Government aid. Technical advice and guidance, suggestions for improved methods of manufacture on modern lines and judicious financial help to those who are still struggling with this industry, are very urgently needed. This will no doubt help to produce better material of finer designs, able to stand modern market competition, and to revive this ancient cottage industry.

Felspars for ceramic industry.

The Peninsular gneissic complex affords numerous pegmatite veins rich in felspars. But in most cases, as the rocks are not very coarse and the felspar is intimately mixed with quartz and other minerals, its separation becomes impracticable.

However, specific instances where very coarse pegmatites occur capable of yielding good quality felspars for economic utilisation, have been noted in the following localities. The weathered rocks may be quarried and the felspars separated by hand picking.

1. Felspars in pegmatites in association with the quartz reef south-south-east of Momnapuram. The quartz and felspars are intimately intergrown, but there are some patches where the felspars are developed in big crystals about 2-3 inches long, which could be easily hand picked when quarried.

2. Bodagundu hillock, about $\frac{3}{4}$ mile east-north-east of Kotakunda.

Here also the felspars occur in big crystals 2-3 inches long capable of easy separation in weathered portions. These localities are about 8-10 miles from the main road and about 12-14 miles along main road to the nearest Railway Station and hence may not involve any great expense or transport difficulties.

Serpentinous deposit.

Just east of Abhangapur by the side of a *nullah* there is a small ridge about 2 furlongs long and about 80-100 ft. wide. This is composed of a soft white material with a greenish to yellowish tinge, sometimes with a brown coating. It does not easily break under the hammer but becomes into powder. It is soft and soapy to the touch and does not effervesce with acid. It is easily scratched by a knife and the local villagers use the material for making small balls for use as shots for their country blunderbusses. The rock is highly weathered and appears to consist of talcose and serpentinous material.

Copper.

Near Ramasamudram, at the margin of the Jaklair Dharwar band, there are scattered fragments of pink mottled quartzitic rocks. Some of the stray pieces show green

malachite. The exposure *in situ* of the mineral occurrence could not be located, the area being covered by black cotton soil and quartzitic fragments.

Another similar occurrence of copper in a white quartzitic exposure was noted near a Dharwar schist patch on the Karni-Kalwal track. A piece broken from the outcrop, on examination indicated copper ore, but nothing more was found.

Archæological finds.

During the course of the survey, sites of archæological interest have also been noted. These finds include stone circles, stone alignments, neolithic artifacts and rock paintings.

A number of archæological finds have been noted along the north bank of the Kistna river from near Thangedi near the Kistna-Bhima confluence to beyond Mudumala up to Angunda in the east. These finds, consisting of stone circles, huge stone alignments, as at Murardoddi, and the neolithic stone implements, testify to the activity of prehistoric man. That the rich valleys of big rivers formed the haunts of ancient man is fully supported by these remains.

Stone circles.

Numerous stone circles have been noted to the west of Thangedi, south of Gudabelur, about a mile north of Murardoddi on the Gidabelur track, south-south-east of Murardoddi in association with stone alignments, east of Mudumala on the Punjanur track, north of Musalapalli, and near Dadanpalli, all along the north bank of the Kistna river. Similar occurrences have also been noted near the Karni dyke at the crossing of the Panchlingal track, Dupatgattu, on the bank of the Pedda Vagu near Mochintla, east of Sunkaronipalli, north of Madhwaram and huge numbers are to be seen near Musapet to the west of the main road, all round the south of the hill .1956. Some occurrences were also noted near

Rachanhalli in Yadgir Taluq. Most of them which are in the interior are still undisturbed, but those at Musapet are just disappearing under the rude hand of the stone *waddar* and the contractor.

Stone alignments.

There are only a few stone alignments, east of Mudumala, south-east of Murardoddi associated with numerous stone circles, just north of Madhawaram and also on a quartz ridge on the Hindupur-Gudabelur track. The biggest of them is the one near Murardoddi, (See Plate IX, Photo 1).

About a mile South-east of Murardoddi there is a mound which has been studded with numerous boulders, mostly gneissic and rarely of dyke rocks. The apex of the mound is circular, open and free from any boulders. All along the flanks and base of the mound there are a number of stone circles.

Just east of this mound there is an almost square area studded with rough-hewn stone pillars. These pillars are arranged in parallel rows in a north-south direction. The pillars are 14'-16' long and 6'-11' in girth. There are 31 pillars still standing and many have fallen down. The square measures about 200' × 200' with apparently 6 pillars in each row. (See Plate IX, photo 1).

'These pillars are locally known as "Nilu Ralloo" meaning "standing stones." The local legend is as follows :—

In times gone by at the place where the stone alignment now stands, some men and women were harvesting the corn. An old beggar woman came to them for some alms. The people asked her to put her basket down and go and fetch them some "Beedi" leaves. By the time the beggar woman returned with the leaves, the people had filled the basket with sand and rubble and covered the top with a layer of grain. The poor old beggar woman took her basket, which she thought was

ready filled with grain for her, and went a short way when she found that the basket was rather too heavy to be grain. She put the basket down and to her great disappointment discovered the trick. In a fit of anger she cursed them so that all men, women and cattle should become stones and all grains sand. So, to this day they stand petrified in the very postures they were in at the time the curse was chanted. The standing pillars represent the men working, the fallen ones the people lying down, and the huge numbers of the group of short stunted pillars just south-west of this alignment, represent the petrified cattle.

A stray piece of stone axe was picked up from this locality.

Just north of Madhwaram there is a run of a dyke. Near this dyke the remains of what may have once been a stone alignment has been noted. They consist of roughly hewn stunted pillars arranged in rows of apparently seven pillars for each row, so to form a square enclosure. The square is about 150′×150′. Near this there is a long pillar still standing in position. Some stone circles were also noted in the immediate vicinity. The village has no legend to explain this occurrence and the field in which this alignment occurs is called "Nilu Ralloo Cheluka."

Some rough-hewn stone pillars were seen fallen on the ground and partly buried by the earth on the Kundapur-Sanganunpalli track, just south-east of hill △2132. These appear to be the remains of some minor stone alignment; the villagers, however, have no information or legend about this. Two stray pillars of rough-hewn stone were noted standing alone just touching the west bank of Pedda Vagu stream at its crossing with the Kotakunda-Koilkunda motorable track. There are also some 20 other pillars all fallen down, some broken and partly buried in the soil. These are locally known as

"Yenagu Rallu", meaning "Elephant stones." These represent perhaps the remains of some ancient stone alignment.

Neolithic artifacts.

Well shaped and polished neolithic stone axes have been picked up from the following localities :—

1. South-east of Murardoddi in association with stone alignment and stone circles.

2. East of Hindupur near the tank bund.

3. West of Rachanhalli near the gneissic hill on Saidapur track—Yadgir Taluq.

4. Just east of Makhdampur.

5. North of Kalampalli.

6. Just east of Impagat △ 2332.

7. North-east of Kamsanpalli, just east of hill .2066.

8. North-north-east of Kaukuntla near the waste weir of the tank.

9. About two miles east of Kottapalli △ 1568 on Magnur-Kottapalli track.

It is to be mentioned that no definite indication of any neolithic settlement or factory could be found except for some stray occurrences of stone axes in most of the above-mentioned localities.

The occurrence near Rachanpalli is, however, associated with some iron slags and stray pottery. A groved stone was also picked up in association with the neolith.

Rock paintings.

On the top of one of the hills forming the Kundapur hill group marked .2132, there is a curiously shaped boulder on the inner sheltered surface of which some line drawings, apparently with ochre, were noted. The boulder is locally known as "Ratha Rasina Gundu"

meaning "a boulder on which there are written markings." The hill is south of Sanganunpalli and is called "Salirigattu," the part of the hill where the boulder is situated being known as "Pangalraya Voddu," just north-west of hill △ .2132.

The rock is the normal grey and pink granitoid gneiss and the boulder is shaped like the hood of a cobra presenting a sheltered under-surface, the hood forming a sort of roof. On the sheltered surface of the base as well as on the under-surface of the roof-like hood portion of the boulder there are numerous line-drawings in brownish red colour. The patterns are complicated and the impressions are mostly fading away into faint markings. The peculiar position of the markings and their faintness prevented taking any successful photograph with the small field camera. This area is worth further study by the Archæological Department.

APPENDIX.

Underground water resources of parts of Mahbubnagar and Gulbarga districts as studied from well logs.

During the field season 1344 Fasli, it was found necessary to study the condition of drinking water wells in the villages of the area surveyed, which would be of immense help in the work of the Well Sinking Department. As the work of the Well Sinking Department was completed in the Raichur Doab and its activity had to be directed north of the Krishna river, both in Gulbarga and Mahbubnagar districts, the geological Officers working in these areas were requested to collect all available information regarding the village wells, their condition and dimensions, whether sweet or saline, infected by guinea worm or not, usual water-level, the highest water-level, *etc.*

During the course of the survey in 1344 Fasli season, 132 villages were visited and about 700 wells were examined. The details of information of each of these wells were tabulated in statement form. Two statements were prepared.

(*a*) A summary statement of information regarding village wells in parts of Makhtal Taluq (Mahbubnagar district) and Yadgir Taluq (Gulbarga district).

(*b*) A detailed statement of each of the wells inspected in all the 132 villages of Makhtal and Yadgir taluqs.

These data are filed in the Office. Though the information is of great value, yet it is not found necessary to have the mass of data published, as it will be of little general interest.

Side by side with the above work, it was thought necessary to make a rapid summer-water-level survey along prominent sections of the country. The whole work had to be carried out in the very height of summer between 14th and 23rd May 1935.

For this purpose two important sections, one at right angles to the other were chosen.

1. North-south section.

From Perapalli, north of Narayanpet, on the border of the District, via, Narayanpet, Makhtal, Magnur, to Mudumala on the north bank of the Krishna river, a total length of about 35 miles.

2. West-east section.

From Yadgir Railway Station on the west, through Yadgir, Yalar, Narayanpet, thence along the main road, via, Marikal, Devarkadra to Mahbubnagar on the east; a total distance of about 70 miles.

Thus a total length of 105 miles of the country had to be rapidly traversed in a very short period.

The plan of work was to take the water-levels of as many wells as possible in the line of section. Details of the summer-water-level, and the highest water-level of each of the 255 wells along both the lines of section were noted and recorded.

This led to interesting results. The data thus collected were shifted and arranged and two sections showing the ground-level and water-table were prepared. Plate III. shows the plan and profile section with water-level of the country traversed for this purpose.

From the sections, it is clear that though the water-table runs sympathetically with the ground profile, it is not uniform but varies in depth from place to place in the line of section. In a granitoid gneissic country

where there is no regular acquifer responsible for the supply in wells, the water-table is irregular. This naturally depends upon the nature of the rock, cracks and fissures in it, the degree of its decomposition and the thickness of soil mantle over it. The distribution of dykes in the area, and the profile of the country have much to do with the underground water conditions.

The following tables give the summarised data of the summer-water-level survey.

Summer water-level survey 1344 *Fasli.*

Makhtal Taluq (Mahbubnagar district) north to south section from Perapalli in the north, via, Narayanpet, Makhtal, and Magnur to Mudumala on the north bank of the Krishna river. Water levels taken between 14th. and 16th. May 1935/ 8th and 10th Thir 1344 Fasli.

Total length of section about 35 *miles.*

Village or site of well	Water-level	High Water-level	Remarks
1. Bed water-level in the Krishna below ground-level	about 30′	..	
2. Mudumala Average ..	16′	6′	
3. Mudumaladoddi ..	10′		
4. Pinjardoddi	10′		
5. Well between 4 & 5 ..	10′-6″		
6. Well at south end of Magnur tank bund ..	9′		

Total length of section about 35 miles.

Village or site of well	Water-level	High Water-level	Remarks
7. Magnur, average ..	16′		
8. Milestone 105 ..	14′-6″		Kistna station-Makhtal Road.
9. ,, 104/6 ..	16′		
10. Sandapur average ..	18′-3″		
11. Makhtal Telugu Mission well. 102 Milestone ..	19′-6″	13′	
12. 102/2 Milestone ..	12′	3′-6″	
13. Makhtal average. West end of town ..	25′		
Middle ,, ..	18′		
East end of town ..	12′-6″		
14. Well No. 1 (see map) ..	25′-6″	16′	Makhtal-Narayanpet Road.
15. ,, 2 ..	5′	2′	
16. ,, 3 ..	18′	10′	
17. ,, 4 ..	19′-6″	8′	
18. Upparpalli	9′	2′	
19. Well No. 5	13′-6″	7′	
20. Well No. 6	12′	6′	
21. ,, 7	28′	23′	
22. Lingampalli road side draw well	19′-6″	11′	

Total length of section 70 miles

Village or site of well	Water level	High Water-level	Remarks
Village average ..	9'-6"	G.L.	
23. Well No. 8 (see map) ..	12'	4'-6"	Makhtal-Narayanpet Road.
24. ,, 9	16'	9'-6"	
25. ,, 10	26'-6"		
26. ,, 11	9'-6"	4'-6"	
27. Utkur.—			
East part of village ..	25'	19'-10"	
West part ,, ..	17'	9'-3"	
28. Thipraspalli, (Average) ..	20'-6"	15'	
29. Wallampalli (Orabhavi) ..	31'	22'-6"	
30. Well No. 12 (see map) ..	4'	G. L.	
31. ,, 13	4'	0'-6"	
32. ,, 14	16'-6"	(New well).	
33. ,, 15	4'	1'	
34. ,, 16	11'	6'	
35. ,, 17	11'-6"	8'-6"	
36. Narayanpet (Average) ..	18-'3"	12'	
37. Well No. 18	4'-6'	1'-6"	Narayanpet-Perapalli track.
38. Perapalli (Average) ..	3'-9"	0'-6"	

Summer water-level survey 1344 *Fasli.*

West to East section through parts of Yadgir Taluq, (Gulbarga District), Makhtal Taluq (Mahbubnagar District) and Mahbubnagar Taluq, from Yadgir Railway Station, via, Yadgir, Yalar to Narayanpet, Marikal, Devarkadra to Mahbubnagar, water-levels taken between 17th and 23rd. May 1935/9th and 17th Thir 1344 F.

Total length of section 70 *miles.*

Village or site of well	Water-level	High Water-level	Remarks
1. Yadgir P.W.D. I.B. Well .	11′	8′	
2. Yadgir Buzurg (Railway Station extension, average	28′-3″	14′-7″	
3. Yadgir Khurd, town ..	24′	8′	
4. Warkanhalli	16′-6″	5″	
5. Maskanhalli	12′-6″	2′	
6. Mallapur	12′-6″	2′	
7. Gopalpur	14′	5′	
8. Yalar—average ..	15′	8′	
9. Well about a mile east of Yalar, marked X on map	18′	10′-6″	
10. Kankal—average ..	18′-6″	11′	
11. Well west of Jalapur marked 'Y' on map ..	7′-6″	4′-6″	

Total length of section about 35 miles.

Village or site of well	Water-level	High Water-level	Remarks
12. Jalapur average ..	12'-3"	9'	
13. Well at 17/4 Milestone marked W1 West of Bhairamkonda. ..	7'-6"	6'-6"	Narayanpet Road Station-Narayanpet Road.
14. Bhairamkonda, average ..	13'-4"	2'-8"	
15. 18/2—18/3 Milestone well marked W2.. ..	13'	4'-6"	
16 19/1—19/2 Milestone south of road ..	10'	1'-6"	
17. 19/6—19/7 south of road..	9'-6"	5'	
18. 20 Milestone south of road	17'	11'-6"	
19. Narayanpet, average ..	18'-3"	12'	
20. Milestone 16/6 north of road marked (1) on map.	10'	4'-6"	Narayanpet Marikal road.
21. Milestone 16/6 south of road marked (2) on map.	8'-3"	3'	Narayanpet-Marikal road.
22. Milestone 16/4 south of road (3) ..	12'	9'	
23. ,, 16/3 North of (4)	3'-6"	2'	
24. ,, 15/5-4 south of road (5) ..	13'-6"	12'	
25. Jajapur average ..	15'-2"	9'-6"	
26. Apakapalli, average ..	29'-9"	19'-9"	

Total length of section 70 miles

Village or site of well	Water-level	High Water level	Remarks
27. Milestone 13/1 north of road (6) ..	9′	G. L.	
28. Milestone 12/7 north of road (7) ..	10′-6″	5′	
29. Chinna Jettum, average ..	14′	5′	
30. M.S.10/3 north of road (8)	11′	2′-6″	
31. ,, 9 ,, (9)	18′	10′	
32. ,, 9 south of road (10)	17′	3′	
33. ,, 7/6 ,, (11)..	12′	6′-6″	
34. ,, 6/5 ,, (12)..	6′	1′	
35. ,, 6/2 ,, (13)..	8′-6″	3′-6″	
36. ,, 6 north of road (14)..	8′-6″	2′-6″	
37. Dhanwada, M.S. 5/4 south of road .	20′	10′-6″	
38. Dhanwada village, average	11′-5″	4′-5″	
39. Abbaspalli, average ..	22′-9″	13′-9″	
40. M.S. 5/1 south of road (15)	18′	6′	
41. ,, 4/2 north of road (16)	13′	4′	
42. ,, 3/6-5 south of road (17)	16′-6″	6′-6″	

Total length of section 70 *miles*

Village or site of well	Water-level	High Water-level	Remarks
43. M.S. 3/4-3 south of road(18)	9'-6"	3'-6"	
44. ,, 3rd ,, (19)	13'-6"	5'-6"	
45. ,, 2/4-3 ,, (20)	15'	G. L.	
46. ,, 2nd. north of road (21)	8'-6"	G. L.	
47. ,, ,, south of road (22)	10'	,,	
48. ,, 1/4 ,, (23)	8'-6"	1'-6"	
49. ,, 1/2 north of road (24)	9'-6"	1'-6"	
50. Marikal, village average ..	18'-4"	8'-8"	
51. M.S. 83 south of road (25)	11'	2'	Marikal-Maha-bubnagar road.
52. ,, 82/6 ,, (26)	6'	1'	
53. ,, 82/2 north of road (27)	14'-6"	9'	
54. ,, ,, ,, (28)	20'-6"	15'	
55. ,, ,, ,, (29)	25'-6"	19'-6"	
56. ,, 81/6-5 south of road (30)	9'	1'	
57. ,, 81/6-5 ,, (31)	8'-6"	2'	
58. ,, ,, ,, (32)	14'	8'-6"	
59. ,, 81/1 ,, (33)	11'	5'	

Total length of section 70 *miles*

Village or site of well	Water-level	High Water-level	Remarks
60. Bandrapalli	6'-6"	G. L.	
61. Gopalpur average ..	12'-2"	4'-9"	
62. M.S. 78/0-1 north of road (34)	13'-6"	G. L.	
63. ,, 77/1 ,, (35)	12'-6"	3'-6"	
64. Devarkadra, Town nearer the road, average	15'-6"	6'-7"	
Further south ..	30'	13'-6"	
65. Devarkadra Railway Station well. (36)	26'-6"	20'	
66. M.S. 75/7 east of road (37)	9'	1'-6"	
67. ,, ,, west of road (38)	8'-6"	2'-6"	
68. ,, 75/4 east of road (39)	14'	8'	
69. ,, 74/6 ,, (40)	14'	7'-6"	
70. ,, 74 north of road (41)	13'	8'	
71. ,, 73/4 ,, (42)	9'	4'-6"	
72. ,, 72/6 ,, (43)	7'-6"	1'-6"	
73. ,, 72/3 ,, (44)	8'	3'	
74. Oblaipalli	14'	5'	
75. M.S. 71/5-6 north of road (45)	24'	9'	

Total length of section 70 miles

Village or site of well	Water-level	High Water-level	Remarks
76. M.S. 71-70/7 south of Road (46)	4'-6"	G. L.	
77. Appaipalli, average ..	9'-2"	1'-7"	
78. Kodur Railway Station well .. (47)	12'	2'	
79. M.S. 69/4 north of road (48)	14'-6"	1'-6"	
80. ,, 68/7 south of road (49)	13'-6"	5'	
81. ,, 68/2 north of road (50)	13'-6"	5'	
82. ,, 67/4 south of road (51)	9'	1"	
83. ,, 67/3-4 north of road (52)	10'-6"	1'	
84. Dharmapur, average ..	16'	4'-2"	
85. M.S. 65/6 south of road (53)	7'	G. L.	
86. ,, 65/1 south of road (54)	7'	G. L.	
87. ,, 64/7 ,, (55)	8'	2'	
88. ,, 64/4 ,, (56)	13'-6"	5'	
89. ,, 64/1-2 north of road (57)	19'-6"	9'	
90. ,, 64 ,, (58) (Distillery well).	21'-6"	6'	

Total length of section 70 *miles*

Village or site of well	Water-level	High Water-level	Remarks
91. M.S. 63/5 south of road (59)	16′-6″	6′	
92. ,, 63/3-4 ,, (60)	9′-6″	2′	
93. Mahbubnagar :—			
Palmur	8′-9″	·1′	
Town proper,			
1st set average ..	16′	9′-4″	
2nd. ,, ..	24′-4″	14′-7″	
3rd. ,, ..	14′-7″	7′-10″	
New Town, (Railway Station Extension) average ..	24′-3″	17′-7″	

IV. GEOLOGY OF THE SOUTH AND SOUTH-WESTERN PARTS OF SURAPUR TALUQ OF THE GULBARGA DISTRICT.

By

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The area under report forms the southern and south-western part of Surapur Taluq; its northern limit is defined by Lat. 16° 30′, the eastern limit by Long. 77° 0′, the southern, by the Kistna River, and the western, by the State limits. Muddebihal Taluq of Bijapur District (Bombay) forms the western boundary of this area, and the Raichur District (Hyderabad) the southern; on the other side it is surrounded by Surapur Taluq of Gulbarga District. The area comprised in this report is about 500 Sq. miles.

Physiography.

(a) *Hills :*

Narayanpur hills.

The hill-system of the area has a general NW.-SE. trend. Between Narayanpur, Kodakal, Rayanpal and Jamalpur, massive groups of porphyritic gneisses form a rugged country. They attain a maximum height of about 1,750 ft. and stand out about 250 ft. above the ground level. The Kistna and the Don rivers cut deep gorges through these hills, with vertical cliffs, which sometimes rise to about 200 ft. on either side of the river.

Hunsgi-Halbavi Hills.

The next group of hills spreads out from Hunsgi eastwards to Kakeri, Chenpatan, Raigiri and Halbavi. The highest point here is about 300 ft. above the ground level. These groups of hills are cut by narrow valleys.

A quartz reef between Hebbal Buzurg and Benkanhalli rises into conical hills at its western and eastern extremities. The eastern hill goes by the name of Paramanand Hill and is about 200 ft. high.

Parmanand Hill.

Separated by the Hunsgi-Baichbal *nala* valley, the Surapur range of hills begin about eight miles north-east of the Halbhavi group of hills. The southern spur of the Surapur range comes within the area under report, and forms a prominent landmark.

Surapur Hills.

The Nagarbetta hill about three miles to the north-west of Nalatwar, rises to a height of 2,114 ft. and is the highest point in the area forming a conspicuous hill above the surrounding country.

Nagarbetta Hill.

All these hills are of relict type and are for the most part rocky and barren.

(*b*) *Tablelands :*

North of Hebbal and Isampur, a fairly large tableland fringes the valley of Hunsgi *nala*. This tableland is capped by limestones and a thin mantle of black cotton soil.

Hebal-Isampur Plateau.

To the south-east of Hunsgi, the Karianigudda, with its shales and Deccan Traps overlying the gneissic ridge, forms an almost circular plateau about a mile in diameter and is covered by black cotton soil.

Karianigudda.

An elongated plateau formed of limestones extends for about three miles to the north of the Diamanhal, Rajan Kollur-Hagratgi line and broadens out outside the State limits, sending out spurs in the State boundary further north, towards Kolihal. This is separated from

Diamanhal-Hagratgi Plateau

the Tirth-Budihal plateau to its south by a deep valley. The Tirth-Budihal plateau consists of quartzitic sandstones grading into shales.

(*c*) *Drainage* (*River system*) :

Main system of drainages.

The main drainage of the area is from south-west to north-east, which is defined by the course of the river Kistna.

Secondary system of drainage.

The secondary system of drainage controlled by the hills and tablelands is from north-west to south-east, occasionally changing to east and west.

The Kistna.

The Kistna river enters Surapur Taluq about four miles south-east of Nalatvad, branching into several channels and surrounding the rocky and barren islands of Janjargadda, Mailgadda, and Devargadda. These branches reunite between Narayanpur and Jaldrug and branch out again immediately into two main streams, the northern stream forming the boundary of Surapur Taluq. South of Jamalpur, this northern stream branches into a number of minor channels, which reunite and rebranch again and form a single river near Bandori. The island enclosed by these streams are mostly rocky with sand and pebbles in places and support shrubby vegetation. (Plate VII, photo 2).

The Jaldurg Fort is constructed on an isolated hill on one such island and must have been an impregnable natural stronghold in historic times.

The deep gorges between Narayanpur and Jamalpur point to the enormous time that it must have taken for the Kistna to cut down through the thickness of the hard gneisses to its present level. The river water, after its confluence with the Don River is slightly brackish but higher up its course it is sweet.

The Don is the next important river that flows through the area. It enters the State limits about three miles south of Talikota and meanders south-east, cutting through the gneissic hills to the south of Kodekal, and joins the Kistna three miles south-west of Jamalpur. The river is perennial, but its waters are notoriously brackish.

Don River.

A perennial *nala* starts near Hunsgi village and flows eastwards for about 14 miles before emptying itself into the Kistna near Shelgi. The water in the Hunsgi *nala* is sweet till it is joined by the Baichbal *nala* near Hebal Khurd.

The Hunsgi Nala.

A number of minor streams take origin in the groups of hills situated in the area and wind their way to the Kistna. They are dry for a greater part of the year. During the summer months, the dry and sandy beds of these *nalas* are covered with thick saline efflorescence which is scraped up and utilised for the salt industry that is still straggling on in the area.

Minor streams

(*d*) *Waterfall.*

From Narayanpur to Jaldrug Fort, the Kistna river flows over a rocky bed, giving rise to a number of cataracts; the biggest of these, east of Narayanpur, has a drop of 60 ft. The waterfall presents an awe-inspiring spectacle, with its white foam, spray and terrific noise. The Jaldrug Fall is a spot of scenic grandeur when the river is in full flood.

Jaldrug Falls.

The Hunsgi *nala* flowing over the massive jointed limestones underlain by shales has a drop of about 15 ft. near Chennur village, (*Vide* Plate VII, photo 4). The total width of the *nala* is about 100 yards and during the monsoon the fall is said to present a beautiful spectacle.

The Chennur Fall.

(*e*) *Springs.*

A number of perennial springs were noted in the area and some of the more important ones are described here.

Tanumandi Tanda & valley.

The Hunsgi group of hills ends west of Tanumandi Tanda, where a spring issues from amidst the jointed gneisses at a point about 30 ft. above the base of the hill. It is said that this spring never dries up even during drought.

Artesian spring at Wajal.

At Wajal, between a submerged temple and the *nala*, is a semi-circular sandy bed from which a very large number of artesian springs spout above the sandy bed. The force behind these springs is such that the water rises about 6″ to 18″ above the point of issue. The spring water is slightly warmer than the *nala* water. There are over 20 such artesian springs in this small semi-circular area, which is about 25 ft. in diameter. The junction of the shales and limestones is a little below the bed level of the *nala*.

It was found that besides these prominent springs along the *nala* there were several other such junction springs replenishing the Hunsgi *nala* with large quantities of water, only a small part of which is used for irrigation near Wajal and Chennur.

Maralbhavi spring.

North of Maralbhavi, a number of springs are seen issuing from the junction of limestones and shales and replenishing a small *nala*. The limestone beds surrounding Maralbhavi on almost all sides and attaining a thickness of about 250 ft. above the shales, account for the springs. Here, too, the bedded limestones are highly jointed. The rain water percolates through the black cotton soil and works down through the joints

in limestones to the impervious layers of shales, whence it issues as springs. The catchment area here, as at Chennur and Wajal, is fairly extensive.

Rajan Kollur-Tirth spring.

A number of springs are seen between Rajan Kollur and Tirth, at the junction of shales and sandstones. It is significant that whereas along this line, perennial shallow wells exist, a few hundred yards further south, in the gneissic country, wells have to go deep to tap dependable water.

Kamnatgi Toldinni springs

A number of minor springs are seen at the junction of gneisses and sandstones between Kamnatgi and Toldinni villages. Some of these are said never to dry up, and they water garden crops.

The springs in the area owe their origin to the junction of different types of geological formations.

(*f*) *Water-level.*

Water-level.

The general summer water-level in this area varies from about 20 ft. to 40 ft. below ground-level. There is no definite water-table in the gneissic country, but in sedimentary formations, the junction of two types of rocks usually gives rise to perennial wells.

(*g*) *Climate*

Climate.

The south-west monsoon is the principal source of rainfall in this area. The monsoon generally begins about the third week of June and continues for three months. A very small amount of rain is also brought by the north-east monsoon, but its contribution here is negligible. Just as is Raichur district, it is subject to insecure rainfall and consequent visitation of famine. The average rainfall is about 25". The summer is excessively

hot, a temperature of about 110° F. in the shade being not unusual. The winter months are pleasant. On the whole, the climate is dry and healthy.

Geological formations.

The geological formations met with in the area are from the Archæans to Recent, and they may be tabulated as below in ascending order.

(9) Soil and Recent deposits.

(8) Deccan Trap.

(7) Infra-trappean rocks.

(6) Vindhyan dykes.

(5) Upper Bhima Series, represented by limestones.

(4) Lower Bhima Series, consisting of basal conglomerates, sandstones, and shales.

(3) Dolerite dykes.

(2) Peninsular Crystalline Complex.

(1) Dharwar Series, (hornblende schists and associated rocks).

(1) *Dharwar Series.*

The Dharwar Series occur only as minor patches and shredded outcrops in the area and are represented by hornblende schists, "Champion gneisses," and epidiorites. Their strike disposition varies from N.N.W.—S.S.E. to N.W.—S.E. They generally dip S.W. at high angles. The more important of these patches are described here.

Shelgi patch. A narrow band of hornblende schist outcrops between Gudihal and Shelgi. South of Shelgi village, schists are seen as lenses a few hundred feet long enclosed by grey gneisses, but outcrop further north and run for over a mile and a half with a north-west to south-east

trend, dipping south-west at 70°. The schists are assimilated by gneisses along the margin, giving rise to siliceous and epidioritic varieties along the contact zone; ribbed weathering is characterisitic. A number of pegmatites cut through the schist patch at various places.

North-west of Shelgi, on the mound formed by schists, iron ore and slags are scattered. Further north, along the Shelgi-Surapur track, the hornblende schists are highly chloritised. Their margin is masked by a cover of black cotton soil.

Between Kodimatti and Surapur a few patches of hornblende schists are seen intimately intermingled with gneisses, giving rise to hybrid types. They run for a distance of a few hundred yards, north of Kodimatti.

Shelgi fault.

An interesting structure noted on the bank of the Kistna south of Shelgi deserves description. Half-a-mile east of Shelgi-mantap, an outcrop of schists, about two hundred yards in length, is observed along the strike of the major schist patch to the north. This outcrop disappears abruptly in the bed of the river on the north bank, but its continuity is traced on the south bank, north of Mudgota, with a lateral displacement of about half-a-mile, indicating a clear fault transverse to the strike.

Mudgota Schists.

On the south bank of the Kistna north of Mudgota village in Deodurg Taluq, extensive outcrops of hornblende and mica schists were noted. These are siliceous along the margins and sometimes give rise to autoclastic breccia. The schists strike north 30° west and dip south 60° west at about 60°. A ferruginous quartzite reef runs through the schists obliquely, in a north-east-south-west direction. Dykes with exfoliating weathering flank the schist patch and tourmaline-bearing pegmatites run parallel to them.

Lenses of schists amidst gneisses-minor patches.

In the hills between Kakeri and Chanpatan, the hornblende schists often form lenticular xenoliths in pink porphyritic gneisses. The gneisses in the vicinity of the schists often show assimilated hornblende. A few minor patches of hornblende schists were seen at Kakeri, Hosur, Edalbavi and in an island formed by a branch of the Kistna south of Edalbavi as also south of Gaddalmari. They are of no importance economically.

Dharwar rocks in the western part of Surapur Taluq.

West of longitude 76° 30′, the hornblende schists fringe the sandstones of Lower Bhima age near Karkanhal, Madlingadhalli and Basapur, near the western boundary of the State. These occur as disconnected patches, separated by bays of gneisses. Red syenites occur as veins along the contact zone of the peninsular complex with the Dharwars.

Tinthini patch.

Another important outcrop of the Dharwar formations occurs north of Tinthini village on the north bank of the Kistna. Here the schists are mainly of the diabasic type and are highly mineralised, studded with pyrite, chalcopyrite, arsenopyrite, etc. They are cut by dirty white quartz veins carrying specular iron-ore and chalcopyrite.

In this schist band there is a deep trench extending for about a quarter of a mile, along the strike of the schists, cut by mining companies that were recently working gold in Raichur District and Surapur Taluq. Fragments of quartz from this trench were collected, powdered and panned. The tailings showed traces of gold with much of pyrite and chalcopyrite. North-north-east of Tinthini, on a small hillock of gneisses, a few depressions and "*Mullackers*" for grinding quartz, such as those seen near Muski old gold workings are found.

Several gneissic mounds in the vicinity of this schist band are strewn with slag. Tradition connects the slag around Tinthini to the *Panchala* caste reformer Manappa, who is said to have worked and lived here as a miner and a blacksmith, in the days of the Adilshahi Kings. The slag which is extensively strewn round about the trappoid schist is collected and carried away as sacred relics by pilgrims who visit the place in their thousands during the Jatra in the month of February. If the slag is of iron, it seems clear that the trappoid schists could not have afforded the necessary raw materials and the ores must have been brought from some other locality. The ancient workings in Tinthini, which go back to prehistoric times, were probably for copper or gold and not for iron.

Slags around Tinthini.

On the south-western side of the Tinthini Santhapur hills, about a mile south-west of Tinthini, is an entrance built in stone and mortar to an underground passage. It is said that this passage leads to the old workings in the Tinthini schist patch. It certainly seems recent and it would be worth while finding if there is really a subterranean tunnel connecting this opening with the old workings.

Entrance to an underground passage.

As may be seen from the map, the schist patch at Tinthini is lenticular in shape, less than a mile in length and about half a mile wide at its central portion, tapering on its western and eastern sides. It is cut by numerous pink pegmatite veins. The rocks surrounding the schists are the pink porphyritic granites.

Between Sugur and the Kistna, the ravines or *nala* cuttings expose quartz schists, and micaceous quartzites. These are engulfed by Peninsular granitoid gneisses; *lit-par-lit* injections of pegmatites run along the planes of schistosity. On account of a thick soil cover

Acidic schistose rocks of Sugur.

it was not possible to demarcate the limits of this formation accurately. The rocks would probably be included in the '*Champion gneissic group*' of the Mysore geologists.

Parmanand quartz hill.

A prominent reef of mottled quartz, enveloped by decomposed diabasic schists, runs between Benkanhalli and Hebbal Buzurg. This reef is about two miles long with a roughly east-west trend. It forms a conical hill at its eastern extremity, rising to about 200′ above ground-level, and on it is situated the temple of *Paramanand*. From here it runs westwards as a low reef till it again bulges into a conical hill rising to about 150 ft. The schists here not only envelope this dirty white quartz vein but are assimilated by it to a great extent. The quartz and schists are surrounded by pink porphyritic gneisses. Copper and iron staining is frequently noted in this reef. The possibility of locating copper in workable quantity at depth may be worth investigation as staining by copper and iron oxides on the top is generally considered as a favourable indication in geological prospecting.

Epidiorites west of Hagratgi.

A well-defined band of epidiorites occurring about two miles to the west of Hagratgi on the bank of the Don river deserves a special note. The epidiorites run roughly north to south, forming mounds and hillocks. Just south-east of Nagur they are covered by sedimentary sandstones of Lower Bhima age in the *nala* bed, but further south, they occupy the eastern bank of the Don and run for about a mile with an average width of about 100 yards. The exquisite temples of Hagratgi, with heavy and detailed sculpturing, are carved out of these epidiorite rocks.

Sometimes small islands of epidiorites occur amidst gneisses. One such is seen south of Jankanbavi. These

seem very similar to the caught-up patches of hornblende schists, except that they are more completely altered than the former.

In extent, the schists occupy a negligible area here. Economically, too, they are not of importance.

Petrology.

The Dharwar series in the area is but a part of the Dharwars in the Raichur district and they show no special or distinctive features from those of Raichur.

The acidic members of the series, which consist of schistose gneisses and schistose quartzites, occur as a well-defined band between Sugur and the Kistna river and are deserving of a brief description here:

Quartz. The quartz is much crushed and rounded and shows linear arrangements. Under crossed nicols some rounded crystals of quartz occur in a mosaic of much crushed grains of the same mineral (L/17 & L/18).

Felspars. Felspars are mostly orthoclastic and show extensive kaolinisation. They generally occur as crystals surrounded by crushed quartz. Occasionally sericite mica derived from felspar is seen in association (L/17).

Chlorites. Chlorites are identified in parallel arrangement along the folia of the crushed quartz. Augen structure around large rounded plates of quartz is seen in some specimens (L/18).

(2). *Peninsular crystalline complex.*

The Peninsular Crystalline Complex in the area is represented in ascending order by

(*d*) Quartz-epidote reef,

(*c*) Red syenites,

(*b*) Porphyritic gneisses,

and (*a*) Granitoid gneisses of the grey and pink series with associated aplites and pegmatites and quartz veins.

Their distribution is indicated on the map from which it is seen that they are the most extensive formation here.

(a) *The grey and pink series.*

The grey and the pink gneisses are so intimately associated with each other that it is difficult to separate and map them as distinct entities. The gradation from one to the other is often imperceptible. Field evidence, however, indicates that in the intrusion of the Peninsular Complex in the area, the grey series were slightly earlier than the pink. In the following paragraphs, the more prominent occurrences of these members are described.

Surapur Hills.

The hills to the south and south-east of Surapur consist of grey gneisses, grading into the pink variety. Towards Khanapur, across the hills and further south and south-east, grey gneisses are met with. Further east, towards Kupgal, grey and pink gneisses pass imperceptibly into each other. The soil here is mostly sandy.

Kupgal Hill.

Kupgal hill consists of grey gneisses cut by pegmatite veinlets. The gneisses show inclusions of crystals of feldspar along the contact with pegmatite. The weathering of gneisses into tors, with mural jointing, is characteristic. On the Kupgal hill, several natural caves are seen connected by narrow passages, through which one could crawl, and these were perhaps inhabited in prehistoric times. Innumerable relics of neolithic age are found in this isolated hill.

Between Kupgal and Lingadhalli, the soil is sandy with frequent outcrops of grey gneisses. The country

south of Lingadhalli, Chandisurhalli and Advadigi consists of sandy soil with outcrops of grey gneisses showing occasional gradation to the pink variety.

Kodematti Hills.

South of Surapur, the Kodematti hills are more pink than grey and have assimilated in places hornblende schists, giving rise to hybrid types. The gneisses here show major joints running north to south. A few syenitic veins cut through the gneisses in proximity to the caught-up hornblende schists. Further south, fringing the Shelgi patch of schists, as at Anandpur and Chandlapur, the gneisses are more pinkish than grey and show a great intermixture of these two types. Numerous pegmatite veins in broken continuity cut through the gneisses as well as the schists. West of Bevanhalli and Chandlapur, grey gneisses predominate. There are a few hillocks here which weather into massive jointed blocks and form caves, (*Vide* Plate VII photo 1). The soil is mostly sandy and the *nalas* which cut through them contain thick saline efflorescence, mostly of sodium bicarbonate or *Dhoby's* earth (*soud*).

Shelgi and its east.

Between Shelgi Mantap and Mushtihal, grey gneisses weather into boulders and are cut by pink pegmatites. They sometimes include small lenses of hornblende schists. A mile east of Mushtihal, fine-grained pink gneisses show clear intrusive relationship into the grey series. Between Mushtihal and Sugur the gneisses are highly decomposed and are interleaved with pegmatites, the latter showing platy weathering in a north-west to south-east trend.

Grey gneisses of Kamnatgi.

South of Kamnatgi and Belshetihal, the grey gneisses predominate. The same type extends to the east towards Kakeri and further west towards Jamalpur The grey gneisses here are medium to coarse-grained and are usually cut by minor veins of pegmatite.

Pseudo bedded gneisses of Devatkal.

A small hill south of Devatkal shows a pseudo-bedded character with north-west to south-east trend, due to weathering. This feature gives it a peculiar appearance as if it was a sedimentary formation.

(*b*) *Porphyritic Granites*

The porphyritic granites form a distinct group by themselves and are normally clearly intrusive into the grey and pink series, the contact often being well defined. The boundary of the porphyritic granites is demarcated on the map from which it is seen that they occur to the south of the sedimentary formations of the Bhima series. On the north bank of the Kistna river, between Tinthini and Narayanpur, near the Jaldurg falls, they have a NNW—SSE trend; they weather into massive jointed blocks, often curiously piled up and balanced one above the other.

From the regional study of the distribution of the porphyritic granites in Raichur and parts of Gulbarga districts it is noted that they outcrop in great force at the contact zone of the Dharwar Series with the Peninsular Crystalline Complex and that they are rare in the main body of the normal granitoid gneisses. The other important area of their occurrence is at the contact of the Bhima series with the Peninsular Complex. This field relation of the distribution of the porphyritic granites suggests that they have intruded mainly along what may be deemed as zones of weakness. The preponderating occurrence of pegmatites and red syenites more or less parallel to the line of contact of the different geological formations affords another evidence of the planes of weakness of such junction zones.

The groundmass of these gneisses is coarse granitoid, the constituent minerals being white quartz, grey or pink felspar, some hornblende and occasionally biotite. The phenocrysts consist of pink tabular felspars, which are from about half to one inch in length.

The important locations and distribution of the porphyritic gneisses, with their local textural variations, are described below:

Porphyritic gneisses of Tinthini Bachimatti area.

The gneisses to the west of the Bachimatti-Konhal-Tinthini line are porphyritic, with a grey, coarsely crystalline groundmass, and pink phenocrysts of felspars.

In the body of these pink porphyritic members, we meet with islands of fine-grained pink gneisses, often grading into aplitic types; such types are seen in the group of hills a mile and a half west of Benkanhalli (1405′ group of hills). The hill group between Raigiri, Chanpatan, Kakeri and Manjlapur consists of pink porphyritic gneisses, which enclose xenoliths or lenses of hornblende schists. Sometimes, as seen east of △ 1549′ hill, these xenoliths run to over a hundred yards in length with a width of about 50 ft. In the △1549′ hill we occasionally come across fine-grained gneisses which show both pink and grey felspars without porphyritic texture. Very probably these are merely a gradation of the porphyritic group and not to be taken as distinct types. Likewise, the fine-grained pink gneiss observed in 1405′ hill, seems to be a variety of the porphyritic type. This inference is strongly suggested by the *gradual gradation* of the above types to porphyritic varieties, in contrast to the fairly sharply defined boundaries that are observed between the porphyritic group and the grey and pink series of the Peninsular Crystalline Complex.

Porphyritic gneisses of south central area.

The gneisses outcropping south of Hebbal are mostly porphyritic with generally a grey groundmass and pink phenocrysts of feldspar. These are frequently cut by pink pegmatite veins. In the groundmass, besides the essential minerals, ferromagnesian accessories, pyrites

and epidote were also identified. Towards Siddapur, amidst porphyritic gneisses, are seen small patches of grey gneisses. The *Paramanand* hill quartz-reef is enveloped beyond the schist boundary by pink porphyritic gneisses. The fine-grained pink gneisses at the foot of the hill seem to be a variety of the porphyritic type. The Bachimatti hill consists of porphyritic gneisses cut by big veins of pegmatite, on the northern extremity of which sandstones outcrop. The sedimentary rocks generally overlie these gneisses between Bachimatti and Devapur, and further south.

An inlier of porphyritic granite amidst sedimentary rocks near Mallur.

The granitic inlier west of Mallur consists entirely of porphyritic types with grey groundmass and pink phenocrysts of feldspar. This gneissic hill which rises to above 1700 ft. does not show any vestige of the sedimentary formations which must have been laid on it. At the foot of this granitic hill, the shales of the Bhima Series occur undisturbed. The plateaus to the north and west of the granites which rise to over 1800′, *i.e.*, to nearly 100′ above the highest point in this inlier are capped by limestones. The entire absence of the sedimentary rock on the granitoid gneissic hill situated amidst the Bhima formations is a feature that must have resulted from the effects of denudation.

Narayanpur-Jamalpur Hills.

Between Rajankallur and Kodekal, porphyritic granites outcrop for about a mile. The gneissic hills between Narayanpur, Jankambavi, Kodekal and Jamalpur weathering into massive boulders, consist entirely of pink porphyritic gneisses. West of Narayanpur, medium to coarse-grained grey gneisses outcrop again. As already mentioned in the section under physiography, the Kistna-Don rivers cut deep gorges through these hills. The Jaldurg falls, a mile east of Narayanpur, are situated on the contact zone of pink porphyritic gneisses and dolerite dykes.

(c) *Red Syenites.*

The red syenites in the area have a special structural significance. A study of their distribution in the Raichur district and parts of Gulbarga district brings out the fact that, like the porphyritic granites, they are most conspicuously seen along the contact zone of the Dharwars with the Peninsular Crystalline Complex and at their contact with the sedimentary rocks in the body of the Peninsular Complex; away from such contact, the red syenites are extremely rare. On account of this feature, it seems reasonable to associate them with planes of weakness, along junctions of two formations. They are clearly intrusive into the pink porphyritic members as well as into the grey and pink gneisses. They are usually dyke like in disposition and outcrop in proximity to the boundary of the sedimentary formation in broken continuity.

These syenites are mostly brick-red in colour and vary in grain from medium to coarse. Blebs of quartz sometimes occur in them and hornblende is a constant accessory. The felspars are both plagioclase and orthoclase and are greatly kaolinised, with the separation of secondary epidote; occasionally calcite crystals are also recognised in the decomposed felspars.

Red syenites are prominently developed near Bopargi, Kodekal, Rajankollur, Kamnatgi, in the Kistna (Plate VII, Photo 2) and Don basins, and up to about three miles east of Hunsgi. They are seldom more than 100 yards in width and are frequently much narrower, and a few mounds and hillocks are noted east of Bopargi and north-east of Madlingadhalli.

Travertine Deposit.

Between Hebal Buzurg and Wajal, a deposit of white calcareous powder occurs in directional continuity with the red syenites that intrude as veins in the Peninsular Complex at their junction with the limestones of the Bhima

Series. This calcareous deposit is about a mile and a half in length with an average width of 400′ and a thickness of about 15′. The syenites in association with this deposit are highly weathered giving rise to calcareous clay.

An average sample of this calcareous deposit has the following composition.

Insoluble in acid	9.2 %
CO_2	38.5 %
CaO	51.5 %
MgO	0.3 %
	99.5%

Percolating and circulating waters in the limestone areas are charged with carbon dioxide and take in solution calcium carbonate. Junction springs and capillary waters issuing from along the boundary of the limestone beds deposit the calcium carbonate as travertine which has now attained these dimensions through the cumulative process of ages. It is quite conceivable that the calcareous deposit has, to a minor extent, been enriched from the secondary calcium carbonate derived from the alteration of the plagioclase felspars of the associated red syenites. On account of its very high content of calcium carbonate with only traces of injurious ingredients such as iron and magnesium, and also its nearly pure white colour, it is admirably suited for the manufacture of rich lime. On a very conservative estimate, the deposit contains 9,000,000 c. ft. of the material. It is calcined locally for the preparation of lime.

(d) *Quartz Epidote Debris.*

A well-defined reef of quartz epidote rock, (epidosite) much broken up into fragments, runs almost continuously between Hobalkal, Gaddalmari and Kamalpur, for a distance of over twelve miles. The outcrops of this reef are generally masked by extensive spreads of debris

derived from its disintegration, which extend out over half a mile along the run of the outcrops. The disposition of this reef is indicated on the map by the letters Q.E.D. to signify "Quartz Epidote Debris." At several places, especially north of Jamalpur, the quartz epidote rock is intrusive into the pink syenites and may therefore be considered as the latest member of the Peninsular Crystalline Complex.*

(e) *White Quartz Veins.*

In the hills around Siddapur, white vein quartz occur as extensive spreads. Only minor veins were noted *in situ* but it is evident that there must have been many of them. A number of quartz veins between Hobalkal, Sonapur and Hanumanhal are of very good quality. Sometimes they are stained by iron on the surface, but it would be easy to get the required quantity for a glass industry by hand-picking. The Hanumanhal group of quartz veins extend both to the east and west, and the Toldinni vein is very probably a continuation of these. These white quartz veins belong to the period of the Peninsular Complex. The disposition of the important quartz veins is indicated on the map.

Petrology.

Petrologically the members of the Peninsular Crystalline Complex show great similarity to the same group in Raichur district. In structure they vary from nearly granitic to thoroughly gneissic and the texture, too, grades from aplitic to pegmatitic. The colour of the felspar accounts for a distinction of these members into a grey and a pink series. There are, however, no fundamental differences, in their physical, structural and textural features, to differentiate them.

Regionally viewed, the pink members are recognised to be slightly later than the grey series. Frequently the gradation from the one to the other is so gradual as to

* Dr. A. L. Coulson who came across similar quartz epidote pegmatites in the Ceded Districts considers them to have concentrated from the basic trap flows intrusive into the Cuddapahs (Mem. G. S. I. Vol. LXIV. Pt. 1 pp 114–115, 1933).

suggest slow intrusion rather than abrupt intrusive replacement or assimilation.

The mineral constituents in the group show but little variety, hornblende being about the only accessory in addition to quartz and felspars.

Quartz. Quartz occurs in irregular crystals sometimes with fluid inclusions (L/26). The zoning of the quartz is a fairly constant feature and the sections show in association strain phenomenon and marginal crushing (L/13, L/26, L/34 and /L39). Sometimes quartz is intergrown with orthoclase, giving rise to micropegmatite (L/13 and L/39). Occasionally inclusions of needles of apatite occur in quartz (L/24 & L/27). An instance of quartz showing twinning according to the Brazil law was noted in a pink gneiss (L/13), near its contact with hornblende schist.

Felspars. In the granitoid gneisses of the area the most dominant and common felspar is orthoclase, which shows partial kaolinisation and epidotisation. Twinning according to the Carlsbad law is recognised in a few sections (L/13). Plagioclase felspars (albite or oligoclase with polysynthetic twinning) occur in subordinate quantity in some sections (L/26 & L/27). Microcline with typical cross-hatching structure occurs in sections which show crushed quartz in association (L/26 & S/17). Reference has already been made to the intergrowth of quartz and orthoclase felspars in some of the sections.

Hornblende. Hornblende is a frequent accessory in the gneisses. In proximity to the Dharwar patches, it shows greater preponderance and gradually gets scarcer, away from Dharwar areas. This seems to suggest that a great deal of the hornblende which occurs in association with these granitoid gneisses is assimilated from the original hornblende schists.

Normally, hornblende occurs in large hypidiomorphic plates with pleochroism varying from deep green to light green. Prismatic cleavages are very well developed (L/26). Sometimes however, the hornblende is recognised in shredded plates often altering to chlorite with the separation of secondary iron ores (L/13 & L/24).

Instances are not rare in the area, where hornblende shows progressive alteration to biotite (L/27). Secondary biotite derived from hornblende is fairly common in the gneisses.

Apatite. Needles of apatite occur in several sections as inclusions in quartz, felspar and hornblende (L/13, L/27 & L/34).

Secondary Iron Ores. These are mostly magnetite and rarely ilmenite and are common in all sections.

(3). *Dykes (Post-gneissic and pre-Vindhyan).*

In the area under report, two distinct types of basic dykes are recognised. One type is intrusive into the Peninsular Crystalline Complex, and the other cuts through the Bhima series.

Dolerite Dykes. The post-gneissic dykes are doleritic and are conspicuously developed towards the south-west, intruded into porphyritic gneisses which seems to be a zone of crustal weakness. The dykes run for several miles in broken continuity and extend beyond the area under report. The dykes with an east-west trend are more numerous than those with a north-south disposition. By themselves they are narrow and inconspicuous but show to great advantage when they cut through gneissic hills, sending branches and offshoots in all directions.

The dykes weather into rounded boulders of various sizes and sometimes show exfoliation. Often their continuity is inferred in the field from the occurrence of

these isolated bouldery fragments amidst soil. The fine-grained and chilled rocks from the marginal zones of the dykes have afforded in several localities raw material for the manufacture of artefacts by early man. Fragments showing successive stages of chipping as fashioning into artefacts are often seen in the vicinity of such localities.

Surapur Dykes

Some minor outcrops of dykes in the hills south of Surapur run mostly on the flanks of the hills and, send branches in all directions. They are medium-grained.

Anandapur 'Star' Dyke.

On a hill about a mile south-west of Anandapur, a fine-grained dolerite dyke cuts the southern flank of the hill and runs over the summit. At the summit of the hill, the dyke sends out radial branches as a "star dyke." The continuation of this dyke is not seen at the foot of the hill, but is taken up in another hillock to the west-south-west with a lateral displacement. This suggests a fault subsequent to the intrusion of the dyke. The margins of the dyke are chilled. All along the contact with the gneisses there is extensive epidotisation in the gneisses.

Kodematti Dyke.

Another minor dyke runs along the flank of the hill east of Kodematti with a north-south trend.

Mangihal Dyke.

Further west, a dyke, medium to coarse-grained in texture, is seen outcropping between Bachimatti and Surapur, with almost unbroken continuity. It cuts the Mangihal schist patch. A dyke further south of this has only a short extension in the area under report, but continues further north-east.

Lingadhalli-Hosur Dyke.

A dyke outcropping in the hills between Lingadhalli and Gogalgatti runs east and west, with an average width of 50 yards, for about three miles. Here, too, at its intrusive

contact with the gneisses, epidote and pyrite are frequently observed in the gneisses. Staining by copper minerals is seen along the dyke in a few places. This dyke reappears north of Yedlabavi and runs further west towards Rayanpal and Kamalpur, sending minor branches into the gneisses. It is interesting that one of these branch dykes, outcropping north of Bamgudda, continues further north-west and is clearly overlain along with the intruded gneisses, by the Bhima sandstone beds of the Tirth plateau. Contact phenomena are entirely absent at the junction of the dyke and the sandstones and the field relationship shows that the dyke is older than the sandstones.

Areshanker Dyke.

South of this area is a long dyke running from beyond Areshankar through Kotigud and Rayangul to the Kistna near Jaldurg Fort. It is not seen in the bed of the river but outcrops again further south-east and runs as a low wall amidst the gneisses and continues eastwards to beyond the area under report.

Narayanpur Dykes.

The dyke immediately south of Narayanpur causes induration of the porphyritic gneisses along the Jaldurg Falls. This induration has enabled them to resist denudation, as a result of which a ridge is formed parallel to the dyke in the bed of the river giving rise to the famous falls. The dyke further south of this does not outcrop in the bed of the river but can be traced on either bank.

The disposition and extent of all the dykes have been shown on the map.

The other group of dykes which are intrusive into the Bhima series will be described later.

Petrology.

The post-gneissic dolerite dykes, which are well developed in the area, show more or less uniform

structural and mineralogical characteristics. They vary in texture from anemesitic to medium-grained. The same dyke shows different textures at different places in its run.

The margins of the dykes are often chilled and epidote and pyrite are produced in the intruded gneisses at the contact. Mineralogically they consist of augite, basic plagioclase felspars, secondary hornblende, biotite and sometimes pyrite.

Augite. In section, augite appears as colourless to sandy brown plates with nearly right-angled cleavage and high refractive index. The sandy brown section shows a slight pleochroism (L/11, L/12, L/102, L/142, & L/149). Ofter augite shows alteration to hornblende and the successive stages are easily recognised in several sections. An interesting case of one half of a twinned augite crystal altered to hornblende with the other half unaltered, was seen in a section of a dyke specimen from near Rajan Kallur (L/102).

A fine-grained dyke near Kathibanda (L/54) showed paramorphic change of augite to hornblende and in some instances the hornblende was further altered into biotite (L/54 & L/142).

An instance of augite altering to serpentine with the separation of secondary iron ores was seen in a specimen of a medium-grained dyke near Jamalpur. The iron ores occupy the cleavage-planes of the original augite.

Ophitic structure is typically developed in most of the sections.

Felspar. These are generally basic plagioclase and occur in parallel laths and in ophitic relation to augite. Sometimes secondary calcite has separated out from altered plagioclase (L/154 & L/19). Occasionally orthoclase is present near the

contact of the dyke with the granitoid gneiss (L/11) and is most probably a caught up mineral.

Quartz. Quartz occurs in a few cases interstitially in very subordinate quantity (L/11, L/54 & L/102).

Secondary Iron Ores. These are generally magnetite and pyrite and are fairly common in the sections.

Bhima series.

The Bhima series in the area is represented by conglomerates, sandstones, shales and limestones. The classification of Bruce Foote[1] relegating the sandstones and shales to the Lower Bhima and the limestones to the Upper Bhima series is adhered to here.

Age	Rocks	Maximum thickness
Upper Bhima Series	Limestones	250 feet
Lower Bhima Series	Purple shales	150 ,,
	Green shales	50 ,,
	Sandstones	100 ,,
	Conglomerates	30 ,,

The basal bed of conglomerates grades into sandstones, over which siliceous and mud shales lie conformably. The shales are generally green or purple and pass imperceptibly upwards into calcareous shales and limestones. We do not see any break or unconformity between one bed and another, the change from sandstone to shale and shale to limestone being clearly progressive. It may therefore be presumed that sedimentation took place without oscillation of the land surface.

1. Mem. G. S. I. Vol. XII, pp. 139-140 (1876).

The extent of the Bhima series is demarcated on the map, and attention is drawn here to a few salient features of the respective groups in their mode of occurrence and distribution.

(4) *Lower Bhima Series.*

Basal conglomerates.

The basal conglomerate beds are well seen along the margins and average in thickness from 3′ to 30′. The pebbles which make up the conglomerate consist of quartzites, quartz, gneisses and angular fragments of red, undecomposed felspars. The conglomerates are much disintegrated along the boundary line, covering the adjacent ground with debris of small pebbles often exposing inliers of gneisses where denudation has removed the conglomerate beds. North-east of Kamnatgi, the gradation of conglomerates to sandstones is gradual, the several stages from coarse conglomerates to fine-grained sandstones being traceable. West of Belsatihal to Kodekal, the transition is rapid, where, a few feet above the basal conglomerates, fine-grained sandstones are met with. The conglomerates are best developed between Uppaldinni and Bopargi and attain a thickness of about 30 ft. They grade into fine-grained sandstones almost rapidly.

Ripple marks and current bedding.

Between Budihal and Bopargi, ripple-marks are extensively seen along the marginal beds of sandstones. These ripple-marks have acquired sanctity to the local folk as representing "Nag" or "Serpent" in consequence of which quite a number of such outcrops have been used as sites of local temples.

Near Balsatihal the sandstones show ripple-marks and current-bedding. Here the prevailing colour of the sandstones is white, though grey and greenish varieties are seen as local modifications. The sandstones are not ordinarily compact, but become quartzitic locally where they are cut by dykes, as seen near Kamnatgi.

Sandstones of Hebbal Khurd and Bachimatti.

The sandstones between Chickanhalli-Bachimatti (Plate VII, Photo 3.) and Hebbal Khurd directly over leuporphyritic gneisses. The basal conglomerates are missing here, their place being taken by coarse sandstones which grade very rapidly into fine-grained pink and white sandstones, much used as building material. Near Chickanhalli the fine-grained sandstones grade upwards into shales. At Baichmatti the sandstones are fine-grained and are about 20 ft. in thickness. They are pink and white in colour and break into blocks $10' \times 3' \times 4''$ which are quarried for building purposes.

Sandstone plateau of Tirth.

Sandstones grading into siliceous shales form a plateau that extends from Tirth to Kodekal and further west. This plateau is topped by green shales 10 ft. thick. The flaggy sandstones on the Tirth plateau break into slabs of large sizes. It is easy to obtain slabs of 12 ft. $\times$ 10 ft, from an inch to 6 inches thick. The dolmens near Rajankollur are all made of these flaggy sandstones. Some of the individual slabs of the dolmens measure $14' \times 12' \times 2''$. (Plate X, Photo 4).

Flaggy sandstones of the Budihal plateau.

On the plateau north of Budihal, the sandstones are flaggy as at Tirth and also yield blocks of large dimensions that are extensively used in house-building. The sandstones are all stained red on the surface, due to weathering, but a fresh surface is white, showing a few "Liesegang" rings from the diffusion of iron salts by percolating solutions. In texture, the sandstones are medium-grained and moderately compact. These characters hold good over the area up to Bopargi. The sandstones occurring west of Hagratgi, especially towards Kadekalvadi, are mainly ferruginous. The iron here does not show itself as a banded segregation but is uniformly distributed all through the mass of the sandstone beds. From the abundance of iron slags near Hagratgi and Bardanhal in association with transported

debris of these ferruginous sandstones, it seems probable that these sandstones, moderately rich in iron, were smelted. They, however, must have formed only a low-grade ore.

Possibility of using in glass industries.

Representative samples of sandstones were collected for testing their utility in the glass industry and some of the samples were sent by our Department to the Government of India in connection with the enquiry for raw material for the glass industry. The sandstones are all coated red on the surface but when broken, a fresh face is white, with rare tinges of red. To estimate the quantity of sandstones available, a working length of ten miles is assumed (from Tanmandi Tanda to Kodekal), a depth of 15 ft. (which has no overburden) and a width of 300 ft. This gives a cubic content of about 230,000,000 cubic ft. This estimate is on the conservative side.

Outliers of sandstones.

A few outliers of conglomerates and sandstones were noted between Bardanhal and Maranhal and their position is shown on the map. The gneissic country adjacent to these is covered with the debris of disintegrated conglomerates, but the conglomerates do not constiture a continuous bed. This feature enables us to appreciate the original extent of distribution of the sandstone-conglomerate beds in the area, but the region now exposes gneisses and cannot be mapped as sedimentaries.

Likewise erosion along the Don valley has been so extensive as to remove the sedimentary rocks, exposing the basement gneisses. The sandstones continue across the Don valley only up to Nagur, whereas, further south, the Don river exposes gneisses.

Beyond Bopargi, a very thick soil mantle masks the junction line of gneisses and sandstones and the boundary has been demarcated here by connecting outcrops that are few and far between.

Gravel beds near Harhatti.

To the north of Harhatti, on the sandstone plateau, a bed of rounded concretionary pebbles with the surfaces coated black by manganese films is met with, occupying an area of about a mile and a half. They vary in size up to an inch in diameter. A freshly broken surface of these pebbles is extremely fine-grained and siliceous and often exhibits concentration of iron. These gravel beds seem to be superficial and concretionary in origin, derived by the weathering of sandstones.

Shales.

The sandstones are succeeded by shales and grade through siliceous shales to argillaceous shales. These are either green or purple.

Green Shales.

The shales immediately overlying the sandstones are green in colour but higher up they become purple and red. The thickness of the green shales varies from place to place, approaching a maximum of about 50′ as seen on an isolated hill section near Kupi village. They sometimes weather into peculiar shapes, presenting queer patterns of relief. These shales have at present no economic utility, but if a cement industry is ever started here, they will do admirably for mixing with limestones.

Purple Shales.

The purple shales which normally overlie the green shales are by far the best developed members of the Lower Bhima series. They have a thickness of about 150′ and grade into calcareous shales and finally into limestones. The shales constitute hills and tablelands in the area, either capped by limestones, as seen between Devapur and Mallur and between Kupi and Tirth or by Deccan Trap, as seen on the outliers north of Manjilapur and Srinivasapur, as also on the Karianigudda north-east of Mallur, or they alone form hills, as seen near Kupi, Gulbal and Mallur. Rarely, they occupy the low-lying ground also; this is particularly well seen in the low

valley east of Mallur which runs through Benhatti to Hunsgi. They weather locally into soft powdery earth. The purple shales which underlie the Deccan Traps are indurated and when powdered are of a vermilion colour. They are locally used for coating houses. The decomposed green and purple shales are extensively used in pottery.

The maximum thickness of the shale beds in the area is computed to be about 200 feet, as deduced from the hills between Gulbal and Kupi.

Dip of Lower Bhima Series.

The sandstones and shales generally dip north at low angles, from 3° to 6°, but they show high dips along a fault that runs from Hagratgi to Tirth. This fault will be described in a later part of the report.

(5) *Upper Bhima Series.*

Limestones.

The shales grade into limestones which outcrop from about a mile west of Hebbal Khurd and spread out further westward to Wajal, Devapur, Salvadgi, Rajankollur, and Hagratgi. Their extent is demarcated on the map.

Beds conformable north of Chennur.

North of Chennur and Hebal Buzurg the limestones overlie the shales and lie horizontally or nearly so. Further west also, the limestones are seen invariably to rest upon the shales. The limestones north of Hebbal Buzurg and Chennur outcrop at about the 1400′ contour and continue further north and west at higher contours to west of Devapur. On the Rajankollur-Hagratgi plateau they outcrop above the 1650′ contour. The superficial layers of limestone between Hebal and Devapur show innumerable holes, like molluscan borings. These holes vary in diameter from a fraction of an inch to sometimes half an inch or more and extend down to about a foot. They are obviously the solution holes common to limestones in the process of weathering.

Limestones between Hagratgi & Dimanhal.

The limestones on the Hagratgi-Dimanhal plateau are generally cream-coloured and break into flags of large dimensions. They are slightly more siliceous than the Hebbal-Kolihal plateau limestones and are free from solution holes. North of Rajankollur, beds of limestone breaking into 10′ square slabs are quarried.

Where limestones directly overlie gneisses.

Between Hebbal Khurd and Hunsgi, the limestones directly overlie the pink porphyritic gneisses which are intruded by veins of red syenite running more or less parallel to the boundary of limestones. Here, the marginal beds of limestones show high dips (Plate XI, Photo 3), and along the escarpment the beds are thrown pell-mell as surface creeps. There is no evidence here of the lower beds having been caved. This is presumably due to the extension of the basin during the period of the deposition of limestones and is thus a simple overlap.

Types of limestones.

The limestones in the area under report show a fairly wide range in colour and other physical characters. Some generalizations regarding the colour of the limestones hold good over a great part of the area. The limestones that overlie the shales are dull red to purple in colour with greenish blotches. These are succeeded by cream-coloured limestones, which are the most widely distributed types. Those in the neighbourhood of Kolihal and the surrounding hills are black. They are comparatively free from solution holes on the surface, such as were seen between Hebbal Buzurg and Devapur. Buff-coloured limestones occur on the plateau north of Rajankollur and they are more siliceous than the normal limestones.

Generally in all these varieties it is easy to get slabs 6′×4′ and 1′ to 9″ thick. At Rajankollur much bigger slabs up to 12′×10′, are quarried. All these are capable of taking a good polish.

Dip of limestone beds.

The limestone beds normally dip to the north, the amount of dip varying from 2° to 5°. However, between Mallur, and Hunsgi and between Hagratgi and Tirth, the beds have higher dips of about 20° to 50° along the fault line. In both these cases, the dip is to the north. The high dips are invariably confined to the margin of the limestone boundaries and disappear within 600′ from it.

Cherts in limestones.

Chert beds occur interbedded with the harder varieties of limestone such as those seen near Maralbavi, Rajankollur, Tirth, etc. They do not form any continuous layer over a wide area but are developed only locally. They are of variegated colours of red, yellow, grey and blue. Druses containing transparent crystals of quartz are observed in the massive cherts. The cherts attain a thickness of about 10′ west of Tirth along the Tirth-Hagratgi fault line. The localities where they occur are indicated on the geological map.

Composition of limestones.

The limestones in the area show a very high percentage of calcium carbonate, with magnesia and iron in negligible quantities. Representative samples from all over the

area were analysed by Newberry's volumetric method and the results are tabulated below :—

Register No.	Locality	Mg CO_3	$CaCO_3$	Insoluble in acid	Remarks
BSS/11	Marlbavi-Gulbal plateau.	1.1 %	92.0 %	6.9%	
S/84	N. E. of Benkanhalli.	1.1 %	94.6 %	4.3%	Calcite in association.
S/109	Hagratgi plateau.	1.7 %	88.0 %	10.3%	Cherts in association.
BSS/8	Devapur	4.4 %	71.8 %	23.8%	Much weathered
BSS/16	Rajankollur	1.1 %	85.8 %	12.1%	Hard limestones.
BSS/15	Hagratgi	4.2 %	64.8 %	31.0%	Cherts in association.
S/41	Hebal Buzurg.	1.2 %	89.4 %	9.4%	Solution holes.
BSS/12	Wajal	1.2 %	92.0 %	6.8 %	do
BSS/10	Kolihal	0.5 %	84.8 %	14.7%	Silky lustre.
S/97	Tirth	0.2 %	81.8 %	18.0%	Cherts in association.

Faults in the Bhimas.

In the earlier paragraphs, attention was drawn to the existence of abnormal dips in the limestones along certain lines, at their contact with the shales and sandstones. In such localities the shales and sandstones come almost into juxtaposition with the limestones or the shales and sandstones adjacent to these are at about the same or even higher levels than the limestone beds. One fault-line runs from a mile north of Mallur to Wajal. Another fault runs from Tirth to Hagratgi.

Mallur-Wajal fault.

A well-defined fault runs from about a mile north of Mallur eastwards through Devapur to about a mile and a half south-east of Wajal having a total length of about five miles. Tracing the fault from its western limit, it is seen that the shales of the Lower Bhima series and the limestones lie in juxtaposition to each other for about three miles, the shales lying to the south of the fault-line and the limestones to the north of it. Further east, along the fault-line from Devapur to south-east of Wajal, only Peninsular Gneisses outcrop immediately to the south of the faulted limestones, but the shales are seen further south, overlying the gneisses, the intervening beds being obviously removed by denudation. The shale beds south of the fault-line do not show any disturbance. A deep fault valley exposes the sections to the north and south of the fault. The shales to the north are at a much lower level than the corresponding members to the south, and these shales gradually grade into limestones. The limestones, as well as the shales which underlie them, show high dips from 20° to 50° all along the margin. These high dips, which persist along the entire length of the fault-line from west to east, disappear, however, rapidly within about 200 yards north of the fault. The fault runs roughly east to west and the downthrow side is to the north and the amount of throw varies from about 50′ to 75′.

South of the fault line, in the Mallur area, the Deccan Traps overlie the shales on Karianigudda (*vide* Section 1 Plate IV). North of the fault, at about the same level the limestones with high dips are overlain by Deccan Traps. A few hundred yards north, where the contact of Traps and limestones can still be made out, the high dips do not exist. The limestone beds dip quite independently of the Deccan Traps. From an examination of the Traps which overlie the shales and the limestones, it was noted that the same sequence of flows holds good over both of them. From this observation, it is concluded that the fault is pre-trappean in age.

Age of the fault.

The other distinct fault observed in the area runs from about a mile south of Hagratgi to Tirth, from west to east for about five miles. It is interesting that this fault runs parallel to the one described above and appears to have started at a point four miles south of that at which the latter ends. The downthrow is to the north and the amount of throw varies from 50′ to 100′. Along this fault also, the limestones and shales lie in juxtaposition to each other, the limestones being to the north of the fault. As in the case of the fault described above, the limestones and the underlying shales are both disturbed. This disturbance is, however, confined to a narrow belt along the fault-line. These beds to the north of the fault line-dip from about 30° to 50° northwards, but the shales to the south lie undisturbed. Here too a deep fault valley has been formed. A point of interest in this area is the development of massive chert beds in the limestones along the entire length of the fault.

Hagratgi-Tirth fault.

In several localities, thick beds of *kankar* with imbedded angular and rounded fragments of limestones of varying sizes are seen overlying the shales, and are generally adjacent to the limestone boundary. Such

Kankar conglomerates in sedimentary area.

beds are seen near Devapur, Marlbhavi, in the neighbourhood of Hale-Gulbal and Kupi. Due to the entire absence of Deccan Trap fragments in these *kankar* beds, it is inferred that these *kankar* beds are also pre-trappean in age. A careful search along the exposed beds did not disclose any trace of fossils.

(6) *Dykes in the Bhima Series.*

Introduction.

Sir L. L. Fermor in a recent memoir[1] distinguishes two types of basic dykes prior to the Deccan Trap age in the Peninsular India. The one he considers to be contemporaneous with the Dharwar system and the other he distinguishes as lava flows, sills and dykes of Cuddapah age. He is inclined to the view that the latter dykes must be younger than the Cheyair stage of the Cuddapahs. During the course of the survey in Surapur taluq, two instances of dykes clearly intrusive in the sandstones and shales were met with. The sedimentary rocks of the area under report have been given the name of the "Bhima series" by Bruce Foote and from extensive field study he gave them the age of Lower Vindhyans, which in stratigraphic sequence are younger than the Cuddapah series.

Normal dolerite Dykes.

The normal dykes in this area and in Raichur District cut through the Peninsular gneisses and, so far as our observation goes, they can only be called post gneissic. The Cuddapah series of rocks do not occur in the Raichur or Gulbarga Districts and for this reason it has not been possible to determine the relationship of these dykes to the Cuddapahs. In Surapur taluq, a few dykes are noticed running between Rajankollur and Budihal in broken continuity. These dykes are medium to fine-grained, with typical pepper-and-salt colour, and are

1. Mem. G. S. I. Vol. LXX p. 2, p. 13. (1936).

clearly seen to underlie the conglomerate beds (Lower Bhimas) of the Tirth-Budihal plateau, and they emerge just north of Budihal village from below the conglomerate beds with practically the same trend as they have south-east of Tirth, before they are masked by the basal beds of the sedimentaries. Presumably some of the other normal dykes we see in the area are contemporaneous with the dykes described above. This observation enables us to ascribe the age of the usual dolerite dykes only to the post-gneissic but pre-Bhima (Vindhyan) period.

Dykes cutting through Bhimas.

In contrast to these dykes, two other dykes cut not only through the gneisses but also through the sedimentary series. One of them occurs as an almost continuous wall running from near Hunsgi to about a mile north-north-west of Mullur, a distance of about five miles in a roughly EW. direction.

Hunsgi-Mullur dyke.

This dyke varies in width from about 50 to 100 yards, forming locally small mounds and hillocks. Towards its eastern and western ends it cuts through pink porphyritic gneisses but north of Mallur and Benhatti, it is clearly intrusive into sandstones and shales, and xenoliths of them are seen in the dykes north of Benhatti; tongues of the dyke also penetrate the shale and sandstone beds. Though there is little mineralisation along the contact of the dyke and the sandstones, physical changes, such as induration of the sandstones or shales, are universal. North of Mallur xenoliths of limestones are seen in the dyke, although it is not seen to actually cut through any limestone beds.

Though the Deccan Traps occur in proximity to this dyke, they are seen to be distinctly separated from it by sandstones and shales, and field evidence does not indicate genetic relationship between the Deccan Traps and this dyke.

Balsatihal-Kamnatgi-Srinivaspur Dyke

The other dyke which cuts through the sedimentary beds outcrops north of Balsatihal and runs north-eastwards in broken continuity to Kamnatgi, where its traces are lost except for fragmental remains amidst the soil-cover till it is picked up again two miles further, north-west of Kangonhalli. From here it runs north-eastward, parallel to the Hunsgi group of hills for about four miles and emerges from the sedimentary formations into the gneissic area east of Karianigudda hill. The dyke is anemesitic to fine-grained in texture. This also is in proximity to the Deccan Traps capping the Hunsgi Hills but it is clearly separated from them by shales and sandstones. Thus field evidence does not indicate its genetic relation to the Deccan Trap outliers.

Though a part of this dyke is seen to run through gneissic country, its intrusive relation to the shales and sandstones of the Lower Bhima series is clearly seen between Balsatihal and Srinivaspur. All along its contact with the sedimentary formation the most common feature noted is the induration of the beds. Sandstones are altered to quartzites and baking was noticed in the shales. The occurrence of quartzites between Balsatihal and Kamnatgi can only be ascribed to the action of this dyke, as normally the lowermost beds consist of non-quartzitic sandstones.

Age of the Dykes.

From the brief description of the dykes given above it is seen that they are definitely intrusive into the Lower Bhima series. In the area under report they have not been seen to cut through limestones, though the xenolithic inclusions of limestones in the dyke north of Mallur show, that these limestones must already have been deposited prior to the intrusion of the dyke. It is interesting to note that this dyke occurs on the up-throw side of the Salvadgi-Wajal fault in the sedimentary beds.

The fault-line is only about 200 yards north of the dyke and runs parallel to it. It is possible that the dyke did not cut through the upper limestone beds owing to their mechanical resistance to intrusion, or having intruded them, both limestones and dyke have been removed by denudation. The dyke runs so close to the fault and is parallel to it, as to suggest that it occupies a parallel fissure.

In the Balsatihal-Srinivaspur dyke there is complete absence of evidence to suggest its age as being anything but post-Lower Bhima.

On account of the proximity of the Deccan Trap, the possibility of ascribing the dykes to that period has been considered. Two points are definitely against such a supposition. In the first place both the dykes are distinctly separated from the outliers of Trap by sedimentary rocks, secondly neither of the dykes show lithological resemblance to the Traps. For these reasons it seems unlikely that they belong to the Deccan Trap period. The possibility of the Deccan Trap flows inducing a local remelting of pre-existing dykes followed by consolidation again with intrusive features in the overlying sandstones and shales was considered. When it is realised that the layers of Trap, even where they actually overlie the sedimentaries produce little or no contact phenomena, it seems most unlikely that it could have induced heat of sufficient intensity to remelt the already existing dykes.

Conclusion.

The two dykes described are later than the Bhima series. Very possibly other dykes cutting through the Peninsular Complex belong to the same set; the instance of these dykes shows that the basic intrusions were not confined only to the Cuddapahs but intruded also the Bhimas.*

*Mr. J. B. Auden reports the occurrence of dolerites intrusive in to the Vindhyan in the Son Valley. (Mem. G.S.I. LXII. Pt. 2. pp. 191—193, 1933).

Petrology.

Lithologically these two dykes are very similar to the usual dolerite dykes of the area. In texture they vary from anemesitic to medium-grained. Tongues of the dykes intruded into the sedimentary rocks are frequent along the contact and xenolithic inclusions of the invaded rock in the dyke are not uncommon. Alteration of the augite to hornblende is widespread in proximity to the limestones and is possibly due to the action of carbonated waters.

The dyke-sandstone and the dyke-limestone contact specimens are interesting and are described below. L/81 is a section of dyke-sandstone contact from near Benhatti. In the sandstone portion of the contact section are seen, amidst rounded grains of quartz, laths of basic plagioclase feldspar and sandy brown augite. The quartz grains show zoning and strain shadows. The dyke portion of the section of contact shows rounded grains of quartz amidst augite and plagioclase feldspars.

The contact specimens of dyke and limestone (L/89) and (L/89B) are described in detail below.

L/89. The limestone portion is more or less uniform and shows crypto-crystalline feature with inclusions of occasional angular crystals of secondary hornblende with linear arrangement. Feldspars are basic plagioclase and are similarly linearly distributed. A tongue of the dyke in the limestone shows laths of basic plagioclase, in ophitic arrangement with augite, which has altered to hornblende with separation of magnetite. At the actual contact with the dyke and the limestone, parallel runs of secondary hornblende and calcite are seen. Strain shadows are prominent in this region. The hornblende sometimes sends small branches into the limestone. Part of the secondary hornblende is changed to chlorite. The dyke portion of this section has all the characteristics of a normal dolerite. In addition, a few crystals of calcite occur as inclusions. Alteration of augite to

serpentine (knitted structure), with the development of magnetite along the cleavages, is characteristic. Basic plagioclase and occasionally orthoclase occur in laths and plates. Both polysynthetic and Carlsbad twinning are common. Some of the feldspars show zoning. The calcite crystals show rhombic cleavages and twinning.

L/89-B near Mallur. The limestone shows cryptocrystalline feature. Along the contact, the limestone shows narrow wavy bands with a great deal of recrystallisation. Green streaks run parallel to these wavy lines.

Feldspars occur in laths in ophitic relation to altered augite, in a groundmass of limestone. The feldspars are mostly basic plagioclase and are changed to epidote and secondary calcite. The augite is altered to serpentine and also to green hornblende. A few isolated grains of quartz can be recognized in the groundmass of limestone, some of which show twinning. Secondary iron ores have separated out from augite.

(7) *Infra-trappean Rocks.*

The shales and limestone of the Bhima series are sometimes overlain by Deccan Trap. Normally the junction does not show any special features. In some places, however, an unconsolidated layer separates the two formations.

Junction of shales and Deccan Traps.

The junction of Deccan Traps and shales (1) on the hills south of Hunsgi and (2) north-east of Mallur deserves special mention.

(1) Geological sequence at Karianigudda near Hunsgi.

The south-easternmost vestige of Deccan Trap in the area is found on Karianigudda hill, about two miles south-east of Hunsgi. The attached transverse section of the hill $\triangle$ 1797′ brings out the relationship of the gneisses, sandstones, shales and the Deccan Trap (*Vide* Section 2, Plate IV). The Deccan Trap occurs

as a roughly circular outlier about a mile in diameter on this hill of quartzitic shales. In between these shales and the Deccan Traps there is an unconsolidated layer of calcareous clay and sand with embedded pebbles of quartzites, sandstones, limestones and gneisses.

Water-worn pebbles on hill 400′ above present bed of Krishna River.

The pebbles vary in size from about an inch to 9 inches in diameter. They are persistent along the entire length of the base of the Deccan Trap and continue towards Thanmadi Tanda, where they overlie the gneissic hills.

On the eastern section of Karianigudda the pebbles are embedded in a layer of loose loam and *kankar* separating the Traps from the shales, but at other places the pebbles are directly scattered on the shales and are overlain by Deccan Traps and further east they are simply strewn over the gneisses.

Origin of the pebble beds.

The existence of these distinctly water-worn pebbles on this isolated hill about 200′ above the present general ground-level gives an indication of the magnitude of erosion of the country during geological ages. These pebble beds are situated about the 1,700′ contour and are about 400′ above the level of the present bed of the Kistna, which flows eight miles further south in a north-easterly direction. There is no indication in the area that this river has had any course here other than its present, and it is not possible to conceive of the pebbles on the Karianigudda being ascribed to the agency of the Kistna. The only explanation that can account for these pebbles at a height of about 200′ from the present general ground-level of this area is that the Deccan Trap cap has preserved remnants of a pre-trappean topographic feature. The sandstones and quartzites show greater development towards the west, on the Tirth plateau at a height of about 1,700′ M.S.L. It seems very likely

that the Tirth plateau originally extended east up to the Hunsgi hills. Streams flowing through such sandstone areas would have brought these pebbles and deposited them at their present position. This suggests that the pre-trappean drainage was from the west to east.

(2) Shale-Deccan Trap junction near Mallur.

The junction of the shales and Deccan Trap north-east of Mallur presents features different from those described above. The shales are capped by a layer of clay, kankar and fragments of limestone and friable powder in places. This layer is about 5' thick and is overlain by the Trap. Only in a few places do we see the direct contact of shales and Trap. In the decomposed layer at a few places are seen some fragments much like fossil roots and plant remains and some suggesting fossil bones. These curiously shaped fragments are invariably enveloped in a fine white powder. These are merely limestone pieces, which have assumed their shape due to weathering. The white calcareous powder in which the curiously shaped specimens are embedded gives the following analysis.

Moisture.	CO_2	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Total
1.20	37.0	9.9	1.6	1.9	47.	01.0	99.6%

The composition of the white bed is more or less analogous to that of the type limestone of the area.

(8) *Deccan Trap.*

In the area under report the Deccan Trap occurs as outliers generally capping the sedimentary formations, and consists of not more than three or four layers. The lowest flow shows an undulating contact with the underlying formations, but the subsequent flows are nearly horizontal.

Deccan Trap outliers on Karianigudda-Hunsgi

About a mile and a half south of Hunsgi, a small group of hills runs for a distance of about two miles. The flanks of the hills up to about the 1,500′ contour consist of pink porphyritic gneisses. These are succeeded by conglomerates, sandstones and shales of the Lower Bhima series. At about the 1,700′ contour, the shales with embedded waterworn pebbles are capped by layers of Deccan Trap. The transverse section of Karianigudda (Section 2, Plate IV) brings out the relation of the Deccan Trap to the other formations. The lowermost layer consists of decomposed greenish Trap with exfoliating boulders. Above this are two other layers of hard Trap. The total thickness of these three layers is computed to be about 90′. The Deccan Trap outliers to the west of this hill show practically the same sequence.

Outliers of Trap north of Mallur.

Capping the shales of the Lower Bhima series there is an outlier of Deccan Trap about a mile long and half a mile wide. Here, too, the Trap-shale junction is roughly near the 1,700′ contour. Another isolated outlier of Trap occurs further north-east, capping limestones on the Kolihal-Isampur plateau, about the 1,700′ contour. Only two flows are recognised here and denudation seems to have removed the upper layers. The lowermost beds weather into greenish material often showing exfoliation, these are succeeded by hard traps. To the west of these outliers are seen the extensive flows of Deccan Trap which continue further beyond the limits of the State into the Bombay Presidency.

Outlier at Nagarbetta.

Adjacent to the village Nagarbetta, about three miles north-west of Nalatvad, there is a conical hill rising to 2,114′. Here the traps directly overlie gneisses and pegmatites and occur about the 1,850′ contour, attaining a thickness of 250′. The following is a succession of Trap flows

as deduced from the escarpment of the hill and their thickness is given approximately :—

Jasparoid laterite	.. 40′
Hard Trap	.. 40′
Decomposed Trap with zeolites; red and pink ..	.. 60′
Hard Trap	.. 30′
Hard Trap with columner jointing	.. 35′
Jointed Trap breaking into boulders 7′×5′×3′	.. 30′
Exfoliating Trap ..	.. 30′
Total thickness of Traps	..265 ft.
Pegmatite debris amidst lithomargic clay	.. 20′
Gneisses	.. ..

The Nagarbetta Hill is seen as a prominent peak for several miles around and is the highest point in the area. It may be noted here that during the course of the survey, most of the nalas and available cuttings were very carefully searched for the sedimentary conglomerates which are reported by Bruce Foote[1] to occur in the vicinity of the foot of Nagarbetta as a thin layer but they could not be located within the State limits.

As Deccan Traps are not seen further south of the outliers described above, they remain now as the southernmost vestiges of the basaltic flows.

(9) *Soil and Recent Formations.*

The soils in the area show an intimate relation to the geological formations. Generally, in proximity to the Peninsular Crystalline Complex, loamy soil is met with. Along the Kistna basin the soil is stony and poor,

1. Mem. G. S. I. Vol. XII p. 185. (1876).

supporting very scanty shrubby vegetation and ill-nourished cultivation. Adjacent to the Dharwar patches black soil is generally encountered. The country covered by the Bhima series, as well as the Deccan Trap, is capped by black soil. Regionally considered, the following instances bring out the above features :

Surapur and Chandisurhal.

The soil between Surapur and Chandisurhal is loamy to sandy. Cultivation is very poor here. South of Surapur hill about two miles north of Shelgi, only sandy soil is met with. Between Shelgi and Sugur is noted a thick black cotton soil mantle. Around Gonhal is thick alluvium. The thick layer of silt supports good agriculture, and garden crops flourish here all through the year.

Soil north of Tinthini.

The Tinthini patch of schists is capped by black cotton soil, but further west and north the ground is covered by rock debris and disintegrated pegmatite. From west of Hebbal-Buzurg right up to the western limits of the State, black cotton soil preponderates, supporting good cultivation. The thickest layer of black cotton soil in the area is seen of the western bank of the Don river and several sections expose as much as about 30′ of soil cover. All along the Kistna basin, as also in the porphyritic gneissic hills north of Narayanpur and Jamalpur, there is hardly any soil over the rocky outcrops and there is little or no cultivation throughout the year. There are, however, pasture grounds which form the grazing area for Surapur taluq even in famine years.

Economics.

Gold.

In the area under report, the occurrences of the Dharwar formations are of very minor significance. The only indications of gold are found in the neighbourhood of Tinthni, where the Dharwar schist band is about a mile long and about four furlongs at its widest. The existence

of ancient old workings was reported by Knight in the eighties of the last century. He found gold in the concentrates of the blue quartz, strewn in the neighbourhood of the old workings.

1. Tinthini.

The Tinthini old workings were trenched by recent mining companies. There is, however, no published record of their findings. The quartz strewn in the vicinity of the trench was powdered and panned during the present survey and an extremely faint indication of gold was observed in the concentrates. Pyrite and chalcopyrite were, however, abundant.

On the gneissic hillocks to the west of the Tinthini patch of schists, there are some '*mullackers*' or gold quartz grinding stones, of various dimensions, similar to those noted at the Maski and Wandalli old gold workings. This points to the ancient gold mining activity near Tinthini.

It is evident that whatever gold ore outcropped on the surface must have been all removed by the ancients and only a deep shaft from the surface to meet the ore-body at depth can reveal the potentialities of the area.

2. Mudgota.

A few man-made depressions amidst the schists near Mudgota on the south bank of the Kistna river seem to indicate a small quartz grinding plant.

3. Mangihal.

The Manglur band of schists continues to Mangihal village as a shredded patch, cut by parallel veins of pegmatite. North-west of Mangihal village are seen a few old workings around which is strewn debris of schists and quartzites. On the gneissic outcrops in the vicinity, are several depressions, presumably for grinding quartz.

Copper
1. Tinthini.

The debris which is seen studded around Tinthini patch of schists contains chalcopyrite and other copper minerals. The trappoid schists and the greyish quartz veins which cut through them show copper minerals in profusion. Pyrites and copper minerals were recovered in the pan in the concentrates of the quartzites in the schists in appreciable quantity. It is widely recognised that copper is one of the zonally distributed minerals and generally separates out at depth. The existence of chalcopyrite in the quartzites and the trappoid schists may be taken as surface indications of copper occurring at depths ; only deep prospecting can disclose the commercial possibilities.

2. Permanand quartzite hill.

The quartzite reef on which is situated the Parmanand temple has been described in the body of the report. This reef is in chloritised and epidiorite schists, and the quartz shows extensive staining on the surface by copper and iron compounds.

All around the hill slags are strewn in profusion, which points to the smelting activity in olden days. The association of megalithic monuments such as stone alignment and stone circle (see section—Archæology) with these slags is of significance. The potentialities of meeting with workable deposits of copper can be gauged only by deep shafts.

Iron.

Though deposits *in situ* of iron ores were not met with in the area, iron slags in good quantity were noted at several places. The most important of these are :—

1. Tinthini.
2. Shelgi.
3. Bardanhal.
4. Kamnatgi.

The profusion of iron slags is not an indication of the occurrence of iron ores of suitable quantity, but it indicates that in bygone ages, when transport facilities were meagre, local self-sufficiency was a necessity. Iron being an indispensable metal was extracted from even the poorest type of iron ore. The ferruginous sandstones west of Hagratgi and the laterite shingle on the Bardan-hal-Bapargi plateau, as well as the magnetite sand concentrate in the Kistna river were some of the probable sources of raw material for the old smelters.

Glass.

Though a number of quartz veins have been noticed they are extensively stained with iron and copper minerals, for this reason, these may be unsuitable in glass industry. There are, however, some excellent deposits of milk-white quartz free from such stains.

1. Between Toldini and Rajankollur, a vein of quartz runs intermittently, often forming mounds and hillocks.

2. About four furlongs west and north-west of Siddapur, are extensive spreads of milk-white quartz, suitable for the glass industry.

3. In the Kistna river south-east of Gadalmari is an island locally called 'Banchigudda,' which consists almost entirely of a blow of quartz of excellent quality.

4. The sandstones on the Kodekal plateau, though stained grey at the surface with iron oxides, are white on a freshly broken face. This sandstone plateau runs for nearly ten miles and it is estimated that about 230,000,000 cubic feet of sandstones without any overburden may easily be obtained in this area, if it can find a use in glass industry.

5. The sandy beds of *nalas* and the river yield attractive raw material for the glass industry. There are indications that there were indigenous glass-smelting

centres in the area till comparatively recent times. At Jamalpur, the furnace and glass slags are still in evidence. Though at present glass is not smelted at Jamalpur, bangles from imported materials are manufactured.

Ceramics.

Numerous pegmatite veins such as at Tinthini, Santapur, Devatkal-Handerhal, Anandapur, and Bhairapur yield large quantities of feldspars. The feldspars can easily be separated from the associated quartz by hand-picking. The suitability of these feldspars for the ceramic industry may be worth investigation.

Potter's clay.

The greenish shales which cap the sandstones near Tirth are used locally by the potters for the preparation of artistic pottery called 'Tirth pottery' and are in great demand on account of their excellent quality. The possibility of utilising this material for a tile and pottery industry needs careful investigation.

Lime and Associated Products.

Calcareous powder.

A deposit of white calcareous powder very rich in lime occurs between Hebal Buzurg and Wajal. This deposit has been described on pages 119 and 120 of the report, and seems to be excellently suited for the manufacture of lime. At a very conservative estimate, about 9,000,000 cubic feet of this material is available for easy exploitation.

Kankar.

Kankar and *kankar*-conglomerates occur at Konhal, between Chickanhalli and Bachimatti, in the Hunsgi *nala*, between Wajal and Hebal Buzurg, south and west of Devapur, and between Maralbhavi and Gulbal. These are of good quality and can be calcined for lime.

Limestones.

The quality and extent of the limestone beds have been described in the body of the report. These are of the required quality for lime and the cement industry.

Salt

In the area under report, a large number of salt works, giving employment to a number of people, still exist. Both edible and 'tanning' salts are manufactured by the process of lixiviation of soils, and of the saline efflorescence from the beds and sides of *nalas*. In the following areas thick saline efflorescence was observed :—

(1) Between Tinthini, Santapur and Chanpatan.
(2) Between Aladhal, Gonhal and Konhal.
(3) West of Chandlapur amidst Toddy palms.
(4) Between Kupgal and Anandapur (Dhobi's earth).

Salt works were noted at the following places :—

(1) A mile north of Gonhal, salt works enclosing an area of 2 furlongs by 2 furlongs.
(2) Between Chandlapur and Bevanhal (edible).
(3) North of Lingadhalli (edible and tanning salts).
(4) Around Hunsgi (edible salt).
(5) Hebbal (tanning and edible salts).
(6) Between Benhatti and Khawajapur (tanning and edible salts).
(7) In several places along the Don river.

It is possible to increase considerably the production of salt in this area as only a very negligible fraction of the saline efflorescence is now actually utilised, locally. If salt works are developed as a cottage industry, there is abundant scope for expansion.

The edible salt is sold locally, but the tanning salts are carted to Yadgiri, the railhead, and thence sent to distant places.

Ochre.

The shales at Karianigudda are capped by Deccan Trap. The beds of shales at the contact have become ochreous. A fairly large quantity of red ochre is available which may have an economic utility in the paint industry.

Building stones.

The area under report abounds in good building stones both for constructional and decorative purposes.

Granitoid gneisses.

A group of gneissic hills between Kakeri, Halbhavi, and Hunsgi consists of granitoid gneisses, in which gradations to fine-grained pink, reddish, and grey varieties are common. These break into fairly large-sized blocks with thicknesses varying from about 4" to a foot or more. They are capable of taking a good polish and on account of their pleasing hues and fine texture, can serve as excellent building material. Several old temple carvings with which the area abounds bear testimony to the use to which they can be put.

Porphyritic gneisses.

A group of crowded hills between Narayanpur, Rayanpal, and Jamalpur consist of porphyritic gneisses with red phenocrysts of feldspar. These are cut by numerous veins of red syenites with inclusions of green pistacite (epidote) and form good decorative stones.

Red syenite.

Red syenites are also met with near Bopargi Bardanhal, Karkanhal, and Rajankollur, sometimes forming hills. On account of their pleasing colour they can be used for decorative purposes.

Epidiorites.

Some outcrops of epidiorites west of Hagratgi have been used for sculpturing the numerous beautiful temples at Hagratgi. In proximity to Kodematti, epidiorites are developed at the contact of Dharwar schists and Peninsular gneisses. These epidiorites can be utilised as building material.

Dolerite dykes.

The numerous dykes vary in texture from anemesitic to medium-grained. These are capable of taking a fine polish and have been used in architectural edifices. A very large quantity of this material is available for exploitation.

Sandstones.

The sandstones around Bachimatti are pinkish grey and white and break into slabs 6′ × 2′ × 1″ They are utilised locally as building-stones and are used for culvert construction on the new Devapur-Hunsgi road.

The sandstones occurring on the Tirth plateau have been extensively used in the group of dolmens, noticed between Rajankollur and Tirth. Some of the slabs measure 15′ × 12′ and vary in thickness from an inch upwards. These flaggy sandstones are excellently suited for flooring and allied purposes.

The sandstones on the Budihal-Kodekal plateau break into suitable blocks for house construction and the houses in Budihal village are constructed almost entirely of these sandstones.

Limestones.

Excellent quality of flaggy limestones in variegated colours yielding large slabs are found abundantly in the area. The prevailing colours are cream, blue, buff, reddish and black.

Cream-coloured varieties are generally seen at Wajal and Devapur. Greenish streaks and patches in these cream-coloured varieties form attractive types. Blue and buff-coloured limestones of dimensions 20′ × 20′ are available in large quantity north of Rajankollur, near Isampur, and at several other places.

Reddish limestones are met with north of Hebbal Buzurg and on the Maralbhavi plateau.

Black limestones are well developed around Kolihal. Massive varieties as well as thin slabs are available in large quantities.

The analyses of representative samples of all these limestones is given on page 135 of the report, from which it may be seen that these are of the required quality, *prima facie*, for the cement industry.

Cherts. Cherts on the Maralbhavi plateau as well as to the west of Hagratgi are of variegated colours and sometimes occur as massive beds. On account of the pleasing shades of colour in which they occur they would be useful for inlaid work.

Deccan Trap. The massive Deccan Traps which occur in the western parts of the Shorapur taluq can be used as durable building stones.

Archæology.

The area under report abounds in interesting pre-historic relics and a separate note has been prepared on these. A very brief account of some of the important occurrences is given below :—

Cave dwelling. Isolated granitoid gneissic hills which during weathering give rise to caves formed an attractive abode for the early man and in this area are found a number of such caves with pre-historic relics. The isolated hill near Kupgal village about five miles south-east of Shorapur contains several relics such as stone age bell (Plate X, photo 2) magical square, stone bruised graffitti, etc., in the hills. North of Hanamsagar there are several caves with local names of which the Chandramma Gavi is the most important. The cave is filled with debris of broken bits of dyke rocks. Not far from here are an ash mound and a stone alignment. A number of caves in the hills to the west of Mallur are in Mudebihal taluq of Bijapur District and contain interesting relics.

Stone bruised graffitti. Generally in association with pre-historic finds such as stone circled graves, cave dwellings, etc., are seen stone bruised graffitti. The important instances are :—

(1) Kupgal hill.

(2) Kathibanda between Siddapur and Hebbal Buzurg.

(3) On hillocks between Chickanhalli and Mangihal.

(4) On the dyke between Benhatti and Mallur.

(5) On a dyke north of Bhairapur.

(6) East of Kodimatti.

(7) On the Karianigudda hill south of Hunsgi.

Stone alignments.

A fairly large number of stone alignments have been located during the course of the work of which the largest which is still nearly intact, is north of Hanamsagar occupying an area of about four square furlongs or more. The other stone alignments are in different stage of mutilation and occur in the following localities :—

(1) Halbhavi.

(2) Bechmatti hill (locally called Gadachumaddi).

(3) Near Paramanand hill south of Benkanhalli (" Halanmardi ").

(4) On Chickanhal-Mangihal track.

(5) North east of Mallur.

(6) Near Rajankollur.

(7) Hagratgi.

(8) One mile north of Hanamsagar (mentioned above).

Stone age gongs.

These are called "Janjan pathar" and are hewn out of clink stone and have diameters varying from an inch to three inches and depth from a fraction of an inch to about an inch. When struck with a piece of rock different metallic notes are produced. The following are the localities of their occurrences :—

(1) Kupgal hill.

(2) South of Devapur hill. (Plate X, photo 3).

(3) North-west of Benhatti.

Stone circled graves.

A large number of stone circled graves are noted at many places in the area, either well preserved, or in a disturbed condition. The sites of these stone circles are enumerated below :—

(1) Near the 20th mile stone on Lingsugur-Shorapur road (near Thinthini village), a group of well preserved stone circles were noted. There were no artefacts found in association.

(2) On Bachimatti-Mangihal track near 1,397′ hill a number of stone circles were noted. There are many broken bits of artefacts in the neighbourhood.

(3) On a southern spur of the Shorapur hills, near Anandpur deserted village, is a fine-grained dyke cutting through the hill and radiating from the centre. At the foot of this hill is an undisturbed stone circle about 100′ in diameter.

(4) At Kodematti hill, a group of stone circles were noted.

(5) A small hill called " Halanmardi " to the south of Paramanand hill and touching it, contains a large number of stone circles. The stone circles consist of quartz and gneissic rocks. A stone alignment, slags and a stone chisel and broken part of an artefact were picked from here.

(6) On the Hebbal Buzurg-Hunsgi track near the calcareous deposits at the brink of limestone plateau, are seen stone circles, and a limestone artefact was picked from here.

(7) On the Chikanhalli-Mangihal path, amidst the gneissic boulders, are seen some stone circles. Some broken parts of artefacts were picked from here.

(8) Two furlongs west of Hunsgi, on the Kamnatgi and Kupi paths, some stone circles are seen in the

lands of Mati Sinappa. Some chipped dyke pieces and rubbing stones were found here.

(9) Near Hunsgi Lambada Thanda, a few very well preserved stone circles are still to be seen. Some chipped bits of sandstones were found here.

(10) On 1,797′ trig. hill near Thanmandi Thanda, a few very well preserved stone circles are still to be seen.

(11) North of Srinivasapur are some stone circles and a sandstone chisel was picked from here.

(12) South of Devapur and in proximity to stone age gongs described in the previous section, are some stone circles in the fields of Dhangar Siddappa.

(13) Near Bhairapur village and on the dyke north of Bhairapur are seen some stone circles and chipped dyke pieces in association.

(14) Near the Vitragal dyke hill and also at the foot of Karianigudda (Mallur) about 30 stone circles are noted. Some artefacts were picked up from here.

(15) In the mutilated dolmen fields north of Mallur, are seen some stone circles with flaked cherts in association.

(16) There are a number of stone circles around Rajankollur; some broken parts of artefacts were picked up in this area.

(17) On Kodekal-Bardhanhal track are some stone circles.

(18) Near Somnath temple south of Madlingadhalli are noted some stone circles. A number of chipped dyke pieces are seen in association.

(19) In the mutilated dolmen field north of Yerkanhal, are seen some stone circles. Chipped dyke pieces are seen in association.

(20) North-east of Maranhal, some stone circles were noted.

(21) Stone circles are noted in several places in Hagratgi lands. There are several chipped stones scattered in this area.

(22) Some stone circles were noted near Yedalbhavi.

(23) At the foot of Karimatti hill which is an island in Krishna river, some stone circles were noted.

(24) On Jamalpur-Gadalmari track in the fields of Jamalpur Manappa some stone circles were noted. There is also a raised platform here which is called "Katti Volay" which means Chabutra lands.

Dolmens.

A number of dolmen sites in different stages of mutilation have been met with in this area of which (*a*) the one at Rajankollur is the largest and still the best preserved (Plate X, photo 4). Theothers are (*b*) on Upaldinni-Hagratgi track, (*c*) north of Yerkanhal, (*d*) between Kupi and Dimanhal, and (*e*) between Mallur and Salvadgi. The dolmens between Kupi and Dimanhal contain cinder and ash circularly placed around the dolmen.

Ash Mounds.

The ash mounds consist of cinder without bones, rubbing stones and artefacts are found in the vicinity. The localities of cinder mounds are :—

(1) Near Thanmandi Thanda.

(2) Halkalappa temple, a mile north of Hanamsagar.

(3) North of Mallur.

Proto-historic sites.

In these places, broken parts of artefacts, chipped and flaked cherts, clay figurines, conch-shell bangles, glass bangles, pot shreds and semi-precious beads are found. The

following are the localities :—

(1) Hagratgi.

(2) Between Rajankollur and Tirth.

(3) Havinhal deserted village west of Devapur.

(4) Between Sugur and Mustihal.

(5) North of Tinthini.

Old Canarese inscriptions have been found in the following localities :—

Old Canarese inscriptions.

(1) Hebbal Buzurg.

(2) Rajankollur.

(3) Hagratgi

(4) Kodekal.

(5) Advadgi.

(6) Kakeri.

(7) On Karianigudda south of Hunsgi.

(8) Kaldevanhalli.

(9) Wajal.

(10) Jaldurg fort (Persian).

(11) Kodekamat (curious markings).

(12) Half a mile north of Narayanpur in the fields on a granite slab are some inscriptions of unusual script (?)

(13) Halkalappa temple in Havinhal deserted village near Devapur.

(14) Shelgi.

V. GEOLOGY OF YADGIR TALUQ, GULBARGA DISTRICT

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Extent.

The area under report is defined on the north by Lat. 17° 00′; on the east by Long. 77° 30′, on the south by Lat. 16° 35′, and is bounded on the west by the river Bhima. It comprises a total area of about 860 sq. miles, lying almost entirely within the Yadgir taluq of the Gulbarga District, except for a small portion in the east, in Maktal taluq, Mahbubnagar District, and Seram taluq in Gulbarga District in the north, together with some portions of Paigahs and Jagirs in the north-west.

Physiography.

A range of hills traverses the area from Narayanpet to near Nalwar Railway Station in a north-west to west-north-west trend and constitutes a prominent watershed. From these two or three spurs jut out to the south for about 4 or 5 miles, enclosing narrow valleys in between. The southern slopes of the range are very abrupt, while to the north they are more gentle but very rugged.

A few granitoid hills occur round about Yadgir, the more conspicuous ones being that south of Kanchgarhalli, Yadgir Hill Fort, and those near Maskanhalli and Balchakar to the east and south-east of Yadgir. South of these hills the country is a rolling plain and to the north it is broken up by small groups of hills.

The average elevation of the hills is about 1,800′, while the plains in the south average 1,300′. In the north-eastern portion of the area the country rises into a tableland about 2,000′ high and is covered by a mantle of rich black cotton soil. A few isolated table-topped hills, however, reach to above 2,300′. The Deccan Trap around Sunknur in the north also forms a small plateau.

The general drainage of the area is to the south and south-west. The Bhima is the only perennial river, and flows in a general south-south-east direction.

Near Gurmatkal a *nullah* has a drop of about 70 ft. and then flows through a deep valley. (*Vide* Plate IX, photo 4).

Vegetation.

The country is devoid of vegetation except for shrubby forests along the slopes of the hills in the north. The southern portion forms a barren sandy plain.

Geological formations.

The geological formations in the area may be classified as follows:—

7. Laterite and soil.
6. Deccan Traps, including Inter-trappeans.
5. Infra-trappeans.
4. Bhima series (Vindhyans).
3. Post-gneissic dolerite dykes.
2. Peninsular Gneissic Complex.
1. Dharwars.

Except for a large spread of Deccan Trap rocks in the north-east corner and a few small patches in the north, and minor developments of the Bhima series in the north and north-west, the area is practically covered by gneisses of the Peninsular Complex. The Dharwars are not well developed and occur in small patches, only a few mappable bands outcropping towards the east.

1. *Dharwars.*

There are only a few patches of Dharwars sufficiently extensive to be mapped, viz. —

Chintalpalli band.
Ashnal patches.
Dugnur patches.
Narayanpet bands.

Chintalpalli band.

To the east of Chintalpalli is a patch of Dharwars about 5 miles long and 2 miles broad. On account of forest growth and absence of sharp boundaries, it was not possible

to define its exact limits. The marginal zones show a great deal of assimilation with the gneisses, and hybridization is widespread along the boundary. An assemblage of the various types of hornblende schist, from the unaltered schists to chloritised and acidic types, can be recognised in this area.

Along the southern portion of the boundary, south of 1893 hill, *lit-par-lit* injections of pegmatite vein the schist band. The pegmatites run parallel to the strike of the schists, which is N. 10° W., and dip vertically. The schists in association with these pegmatite veins, and also those further west, are mostly recrystallised types. Along the southern boundary of the patch the schists grade into epidiorites which show well developed gneissic banding, and at places the schists stand out in ribs due to differential weathering. North of 1893 hill, the hornblende is locally altered into mica. The progressive alteration of the hornblende to mica indicates the degree of metamorphism to which the rock has been subjected.

The gneisses at the contact of schist bands have developed hornblende as a derived mineral, as seen near Dharampur, but the boundary of epidiorite and the hornblende gneisses is so gradual that it is often difficult in the field to determine where the former ends and the latter begins. Silicification of the schists is also noted north of Kandkur. All these are suggestive of the great assimilation and reconstitution to which the rocks of the area have been subjected.

The central and western portion of the Chintalpalli schist band also show progressive stages in metamorphism. The 1947 hill and those to the north of it consist almost exclusively of recrystallised hornblende-schist boulders, exhibiting spheroidal weathering. The rock is composed of large interlocking crystals of hornblende, and is of a black colour and very tough. Similar

types are found on the temple mound on the Chintalpalli tank *bund* but further north and along the eastern margin of the band, epidiorites showing a great deal of assimilation are prominently developed. About two miles north of Chintalpalli a hillock of assimilated schist and gneisses is capped by boulders of fibrous actinolite schist. Occasionally pink and grey aplitic veins cut through the schists and are partly assimilated along their contact.

The eastern and north-eastern parts of the Chintalpalli band consist mainly of fine-grained hornblendic and chloritic schists, though recrystallised varieties are occasionally met with at the contact with members of the Peninsular Complex. Broadly viewed the following distribution of the types may be recognised. At the contact, hybrid varieties with intercalated aplitic and pegmatitic members abound. Typical hornblende and chloritic schists are seen in the eastern portions, and, towards the north, hard fine-grained schist with specks of pyrite and chalcopyrite occurs. Micaceous quartzites occur intimately intercalated with the chloritic schists. In view of the numerous gneissic bays and veins of pegmatites and aplites noted in this schist patch, it is not possible to ascribe all the changes undergone by the schists to any one member of the Peninsular Gneissic group.

An isolated dyke-like outcrop of recrystallised schist occurs east of the patch about a mile east of Chanakar.

Ashnal patches.

Four isolated patches of Dharwars separated by gneisses occur in the Ashnal forest area. The soil over the schist area is reddish, supporting only grass plots.

The three patches to the west of Tatalgiri consist of hornblende-schist, whereas the one to the east is almost completely recrystallised. Small caught-up patches of schists and assimilated rocks are seen interspersed in the gneissic hills.

Dugnur patches.

A large number of minor outcrops occur as inliers amidst gneisses between the villages of Nachwar and Gadedonal. South of Konapur the schist patch is completely recrystallised to coarse hornblende. About a mile south of this, near 1801′ intersection point, a basic dyke is almost entirely altered to soap-stone, and this has been used in the past for making stoneware, the remains of which can be seen along the hillside as broken fragments.

The other outcrops to the south consist mostly of coarse hornblende rock which has been partially assimilated with the aplites and gneisses. North of Nachwar two small areas of Dharwars are seen, which consist mainly of epidiorites with phenocrysts of hornblende.

Narayenpet bands.

Between Gurmatkal and Narayanpet, rocks of the Dharwar facies frequently form dyke-like hills stretching in a general north-north-west south-south-east direction. These hills are composed almost entirely of recrystallised hornblende-rocks, with large crystals of hornblende, frequently having quartz and feldpars distributed in the mass in small specks. The hornblende crystals are also surrounded by a network of these white acidic materials, which gives a honeycomb structure to the rock when the softer hornblende is removed by weathering.

In the southern portion epidiorites preponderate, while in the north the contours rise rapidly to form groups of hills up to 2,000′, consisting entirely of recrystallised hornblende-schists. The amount of quartz and felspars in the rock decreases, and the size of the hornblende crystals increases as one approaches the top of the these hills, until the rock is composed almost entirely of large interlocking hornblende crystals near the summit.

The Dharwar rocks here may be divided into two spindle-shaped bands, but the gneisses cut into them, frequently breaking their continuity. The dotted lines on the map show the range of distribution of the schistose members rather than the actual limits. The area requires a more detailed study.

Petrology.

The hornblende-schists are mostly recrystallised and siliceous. They are medium to coarse-grained and show schistose structure in hand-specimens, and are of a dark greenish colour.

Under the microscope schistosity is not always seen. Hornblende occurs in greenish crystals with characteristic pleochroism and interference colours. Sometimes it is altered to chlorite or epidote, the latter appearing as greenish yellow irregular plates. Both plagioclase and orthoclase felspars occur and are often kaolinised. Interstitial quartz is found in subordinate quantities. A specimen collected north-east of Tatalgiri shows apatite in large quantity.

The highly recrystallised rocks north of Kandkur have developed very large crystals of hornblende and are composed almost entirely of such interlocking crystals, with felspars and a little quartz in the interstices.

Hornblende occurs as large irregular crystals, sometimes enclosing felspars. It alters to biotite, chlorite and actinolite, with separation of secondary iron ores. Sometimes the basal cleavages of the hornblende persist in the biotite. Actinolite occurs in fibrous crystals which are slightly pleochroic. Felspars are kaolinised and epidotised. Quartz is seen in very minute specks in subordinate quantities. Sphene and apatite are also occasionally found.

The epidiorites are medium to coarse-grained and are of varying textures ranging between hornblende-gneiss and recrystallised schist.

Quartz occurs in varying quantities, sometimes forming a large proportion of the thin section and sometimes only a negligible amount. It is nearly always zoned and crushed and shows strain shadows. Orthoclase felspar is more common but plagioclase is also present. The felspars are highly kaolinised and sericitisation is also noticed. Hornblende occurs in fair quantity as greenish pleochroic crystals. It is generally altered to biotite and rarely actinolite has formed. In a specimen collected west of Gungnur calcite has also developed. Epidote occurs as an alteration product of both hornblende and felspars. Apatite and secondary iron ores were noted as accessory minerals.

The hornblende-schists have in places completely altered into actinolite and talc-chlorite-schists, as seen a few miles north of Chintalpalli. They are fine to coarse-grained and highly schistose in texture.

A specimen collected two miles north of Chintalpalli shows pale green fibrous actinolite, slightly pleochroic and with high interference colours. Some crystals show the original prismatic and basal cleavages of hornblende, indicating that the actinolite is a derived product. Pyrite, brassy in reflected light, has formed in large quantities.

Another specimen from near the above and south of 1,793′ point, shows talc in colourless fibres and platy crystals, having a high birefringence like muscovite. Chlorite occurs as broad pale green crystals, sometimes showing vestiges of the original hornblende cleavages. Fibrous masses of serpentine, and secondary iron ores occur as alteration products.

2. *Gneisses.*

The greater part of the area surveyed consists essentially of the Peninsular Crystalline Complex of the grey and pink series.

Regionally viewed the grey gneisses occupy the southern portion of the area. They form large low-lying sandy plains with occasional tors and hills breaking the monotony of the landscape. The villages are few and far between, the sandy soil being incapable of sustaining any heavy cultivation. The gneisses here consist of quartz and felspars and are often cut by pegmatites. The sandy soil is an expression of the paucity of the ferro-magnesian contents in the rock group.

Two miles north-east of Saidapur Railway Station the hill 1410 is composed of coarse-grained banded grey gneiss. The hill is dome-shaped but slightly elongated in a north-west-south-east direction. The rock is cut by two prominent vertical joints, roughly north-south and east-west.

About six miles north of this, near Balchakar, quartz-felspar gneisses form hills rising to 600′ above ground-level. The hills assume a hemispherical dome-like appearance due to the exfoliation of the rock in regular spheroidal scales. In one of the hills, well-developed mural jointing (*Vide* Plate IX, photo 2) gives rise to huge rectangular blocks with steep vertical sides. The rock is coarse-grained with occasional phenocrysts of felspar. The hills are remarkable for the uniformity in the rock composition, hardly any quartz or pegmatite veins or basic segregations being observed.

The next group of hills is seen in the country around the ancient hill fort of Yadgir. Here pink and grey coarse-grained gneisses occur, with innumerable intrusions of associated quartz and pegmatite veins in a roughly north-south disposition. Basic segregations are also common and these have a general west-north-west to east-south-east trend. Yadgir fort is built on a pink gneiss stock. The pegmatites and aplites, together with ferro-magnesian assimilations in the pink rock, give it beautiful banded appearance. The hills surrounding

Yadgir fort are composed of grey and pink gneisses, medium to coarse-grained in texture, weathering into boulders and forming tors. The country between the hills has numerous exposures of quartz-feldspar granites which disintegrate into coarse grit, and of pegmatites which give rise to white calcareous matter and *kankar* deposits.

Hulipet hill 1330 is a small hillock of grey gneisses showing well-developed gneissic banding with mica, quartz and feldspars arranged in alternate bands in a north-north-east—south-south-west trend ; crumpling and foliation in the gneiss is also well seen. Similar rocks extend south-eastwards as far as Sanklapur, and are also seen near Minaspur, at hill 1513, and at Nagarbunda.

The gneisses described above may be considered as normal varieties and it is significant that they are far removed from any schist area. In proximity to the schist area the grey gneisses assimilate a great deal of ferro-magnesian minerals and give rise to complex types. To this group belong the banded biotite-gneisses north-west of Arkeri and those of Makhdampur. Typical banding has developed in the gneisses, characteristic of contact zones, in the outcrops north of Kandkur and south of Gurmatkal.

Synites. Synites of a beautiful pink colour and fine-grained texture are found in proximity to the schist bands, as seen near Bhairamkonda, north of Kandkur and at Makhdampur.

The gneisses to the north and east are mostly pink pegmatoid with a large number of quartz and pegmatite veins. Pink porphyritic gneisses are occasionally met with in the bed of the Bhima river.

Quartz veins. The disposition of the quartz veins associated with the gneisses is indicated on the map. As may be seen, these run in broken continuity in a general north-west—south-east trend,

often forming conspicuous hills separated by plains of quartz debris. Iron-staining on the surface is a universal feature, and the quartz is cut by numerous joints running in all directions. The quartz veins sometimes contain coarse felspars, pointing to the condition of crystallisation of the end product from a normal pegmatite melt.

The most prominent of these quartz veins are those to the west of Arkeri Khurd in the centre of the area surveyed, (*Vide* Plate IX, photo 3). Here three or four parallel veins cut through the gneisses running in a general north-west-south-east direction and form ridges which are covered by small shrubby growths. The largest of these, close to the village of Arkeri Khurd, rises to more than 200' above the surrounding country. These ridges are composed of a fine-grained, milk-white quartz. A type specimen of this quartz gives 97.2 per cent. SiO_2 and it may be possible to get superior varieties by hand-picking and selection.

About two miles south of Arkeri Khurd a large quartz vein runs in the same general direction. This outcrops for about two miles but is not continuous throughout its length. It rises to about 150 ft. above the surrounding sandy plain at its north-western end and forms brownish white hillocks. Similar veins occur north-east of Bandehalli, north of Yadgir and at Arkeri Buzurg further north-west. Besides these, there are other smaller veins with the same general trend.

To the east of the area there occurs a group of quartz veins which are much smaller in size than those mentioned above and have a east-north-east—west-south-west to north-east-south-west trend. They also contain larger quantities of felspars and may be said to be of a pegmatoid nature.

Petrology

Granitoid gneisses. The gneisses are mostly granitoid, fine to medium-grained in texture, and are generally banded.

Quartz is highly crushed and zoned. In a specimen from east of Yadgir the quartz is pitted and cracked and contains fluid inclusions. Pressure is further evidenced in the development of microcline. Orthoclase and plagioclase felspars are kaolinised and sericitised and are sometimes altered to epidote. Hornblende is generally present and shows alteration to chlorite and biotite with separation of secondary iron-ores. Apatite occurs in minute needles enclosed in quartz. Occasionally sphene and leucoxene are also found. In one specimen intersecting veinlets of epidote of a pistachio-green colour are noticed.

The biotite gneisses are easily distinguishable from the above by the fact that they contain a large amount of biotite which is arranged linearly giving a distinct gneissic structure to the rock. This structure is sometimes clearly seen even under the microscope.

The rocks are medium to coarse-grained. Quartz shows strain phenomena and often occurs in micrographic intergrowth with felspars. Microcline occurs abundantly, although orthoclase is the predominant felspar. Plagioclase is also present. The felspars are highly kaolinised. Biotite is very abundant and shows linear arrangement. In a specimen from Hullipet hill 1,330′, pleochroic haloes around zircon grains are observed in the biotite. Apatite is generally found, and other minerals present are augite, hornblende and sphene. Iron-ore and epidote occur as alteration products.

Syenitic gneisses of a deep pink colour occur in a few places in proximity to the Dharwar rocks. They are fine-grained and granulitic to allotriomorphic in texture. Quartz occurs in subordinate quantities. Felspars are red to pink and are kaolinised into pink cloudy stuff. Orthoclase is the more abundant felspar, although microcline and plagioclase are also present. Hornblende occurs in small shreds. Apatite, epidote and secondary iron-

ores are also formed. The scarcity of ferro-magnesian accessories is noticeable.

3. *Dykes.*

A few dolerite dykes occur in the area surveyed, the position of which is marked on the map. They are mostly fine-grained and show the usual characters of post-gneissic dykes. They often run in broken continuity and weather into small rounded boulders. The longest of these runs for about four miles to the south of Malkapalli and has a NE.-SW. trend. It cuts through the gneisses along its entire length and disappears under Deccan Trap south of Siddapur Buzurg.

Another large dyke running north to south occurs north of Gajarkot.

A dyke near Balchakar seems to take a tortuous course, but it is difficult to say whether the different outcrops marked are of the same dyke.

There are other minor dykes distributed throughout the area and they have a roughly east to west trend.

Petrology.

The dykes are chiefly doleritic. They are all black with a greenish tint; weathered surfaces are more or less lateritised. They are fine to medium-grained and generally have an ophitic texture, though rarely porphyritic types are also seen.

The chief mineral present is augite in irregular sandy brown crystals and uralitisation is very marked, hornblende, chlorite, biotite and calcite being developed as alteration products. Plagioclase feldspars occur in typical ophitic growths as laths surrounded by augite and showing alterations in various stages. Other minerals present are sphene, translucent leucoxene, apatite needles and quartz in very subordinate quantity. Secondary iron-ores are also formed.

4. *Bhima Series.*

On account of the small extent over which this sedimentary series is distributed in the area under report, it has not been possible to come to any independent conclusions as regards their stratigraphic position in the Purana group. Bruce Foote's classification of the series is adhered to in the following notes. He considers them to be members of the Vindhyan group and gives them the name of the Bhima series.*

Lower Bhimas.

The Lower Bhima series is represented by horizontally bedded basal conglomerate-sandstones overlain by shales. They occur fringing the Upper Bhima formations to the north of the area near Hundarki and Allur, and outcrop again to the south-west near Nalwar. Their exact location and limits are indicated on the map.

Conglomerate-sandstones.

The basal conglomerates vary in thickness, texture and composition from place to place. To the east of Hundarki the conglomerate-sandstone bed is about two ft. thick and consists of small sub-angular to partially rounded grains of white and bluish quartz and jasper, from a quarter to a tenth of an inch in diameter, embedded in a compact granular siliceous matrix. Small grains of pink felspars, partly decomposed, and biotite, can also be recognised. Yellowish staining by iron is frequently observed in this bed. Further east, to the north-west of Nachwar, these beds thin out and are capped by Deccan Traps. Here they are highly indurated and grade into coarse quartzites with extensive ferruginous staining, giving them a deep red tint.

Two miles south of Hundarki the conglomerates enclose vitreous, translucent, sub-angular to rounded grains of quartz, about a quarter of an inch in diameter, in a quartzitic matrix. Angular grains of

* Bruce Foote, Mem. G. S. I. Vol. XII, 1876.

kaolinised felspar of somewhat smaller size are interspersed amidst the quartz. The weathered surface shows a dull reddish colour.

At the base of the Ladlapur hill the conglomerates grade into a coarse pebbly sandstone and grit, consisting of translucent quartz and angular felspathic fragments. The cementing material is sometimes of an olive-green colour. The thickness of the beds here is between 6" and 18".

The conglomerates are again seen along the western margin of the Sunknur plateau, and about a mile and half north of Nalwar Railway Station, where they are similar in character to those at Ladlapur but of a uniform brown colour. The composition of the conglomerates suggests that the country surrounding their area of deposition was mainly gneissic. The predominance of sub-angular grains in the sandstone indicates that they were not carried far.

Shales.

The shales lie conformably above the conglomerate sandstones and are the best developed members of the Lower Bhima series. They form an escarpment from Holgol running south eastwards for about a mile and then swerving towards south-west to Hundarki. The shales outcrop here in a narrow belt but spread out southwards, east of the Hundarki-Bhimanhalli cart-track. A similar escarpment is formed to the north-west of Ramtirth. The shales are best seen at Ladlapur, where they form a conical hill with steep sides rising to about 200′ above the general ground-level. This may be taken as the maximum thickness of the shale beds in the area. They are exposed again in a fan-like spread north of Nalwar and to a small extent east of Kollur.

The shales immediately overlying the sandstones are dull green and siliceous. At Ladlapur these have a thickness of about 40′, but in other places a clear section

is not visible. South of Hundarki, in proximity to the Deccan Trap, these have been transformed into lithomargic material of a deep vermilion colour. Overlying these greenish beds are purple shales, the upper layers of which grade into calcareous shales. They separate out into thin laminæ about ¼″ thick, but being exceedingly brittle and soft they do not lend themselves to working into roofing tiles. Interleaved with the upper layers are thin beds of grey limestones, about half an inch thick. The purple shales have a maximum thickness of about 150′.

Upper Bhima series limestones.

The purple shales are succeeded by flaggy limestones, which grade into massive beds. The limestones outcrop a little below the 1,700′ contour in the east and at lower levels towards the Bhima to the west and attain a maximum thickness of about 200′. The beds generally separate into slabs 6″ to 12″ thick, but occasionally up to 2 feet or more. Thinner flags are interbedded with these and are quarried in ½″ to 2″ slabs for flooring and other purposes. The beds are generally horizontal, but have a slight inward dip up to 5° away from the margin.

Disturbed beds.

The shales and limestones from Bhimanhalli eastwards are nearly horizontal. To the west of Bhimanhalli the rocks along the margin of the outcrop are tilted and disturbed. They dip 15° to 30° towards the north-east with a north-westerly strike parallel to the outcrop. Further north-west along the boundary the dip gradually increases till at Ramtirth the beds are nearly vertical. This high dip is again seen at Allur hill. The disturbance in the shales and limestone beds is confined to the marginal portions of the outcrop between Bhimanhalli and Allur, and 100 to 200 yds. away from the boundary they gradually resume their normal horizontal disposition. The disturbance

may be attributed to faulting as suggested by Bruce Foote.* It may however be pointed out that this disturbance occurs along the margin of the outcrop of the sedimentary beds, and that no limestones or shales occur on the other side of the fault-line.

Limestone Plateau.

The limestones north of Hundarki form an extensive plateau with no soil-cover. (*Vide* Section Plate V). The rocks here are grey, and break into huge blocks up to 10′ × 10′ × 2′. (In a temple to the west of Bhimanhalli a lamp pillar cut out of this limestone is 16′ high, 2′ square at the base tapering to 12″ at the top. Smaller pillars 18″ to 2′ thick are also used in the construction of the temple). Further west the limestones are covered by black soil. The lower beds around Bhimanhalli show a purple tint and this colour is seen to intensify north of Ramtirth, where thick beds of purple limestones are present. North of Allur the rocks are again drab-grey in colour. Interbedded in these massive limestone beds are bluish flags which split into slabs ½″ to 2″ thick, much valued for flooring purposes. These are quarried about a mile north of Allur Khurd and exported, but a road connection to Wadi would greatly improve the prospects of these quarries.

At Nalwar flooring slabs 2″ thick, of inferior quality are quarried. South-west of Nalwar limestones are exposed all along the river-bed between Maradgi and Turnur. The colour changes from grey at Maradgi to greenish blue and yellow at Turnur. In the latter village the houses are built of this yellow massive limestone, which gives a very pleasing appearance from a distance. About a mile or so to the east the limestone beds disappear under a thick soil-cover of *regur*. Further south the village of Kollur is situated on an exposure of massive grey limestone beds overlying the purple shales

* Mem. G. S. I. Vol. XII, Part 1, pp. 148-149. (1876).

Landslip at Ladlapur.

An interesting case landslip is seen near the conical hill at Ladlapur village. (*Vide* Plate V). This hill is composed entirely of shales, which must have been capped by limestones. The conical shape of the hill suggests that the soft shales were denuded away faster than the overlying limestones and dislodged and brought them down *en masse*. These displaced limestones are now seen lying pell mell as a mass of broken debris to the north-west of the hill.

Caving of the limestones is noticed at the abandoned village of Kalyani, south-east of Kollur. Here a roughly circular outcrop of limestones about 200 yards in diameter shows an inward dip of 12° to 15° round the periphery. It is not certain whether this is due to the removal by solution of either the lower limestone beds or the calcareous shales or, if it is a case of centroclinal folding.

5. *Infra-trappean.*

Underlying the Deccan Traps there sometimes occur unconsolidated deposits of highly decomposed clayey debris. Normally the plane of junction between the basaltic flows and the earlier formations is sharp and not accompanied by any structural or mineralogical peculiarities. In a few sections, however, such as near Gurmatkal, an interesting layer of unconsolidated material varying in thickness from a few inches to about 6′ is seen to intervene between the basement gneisses and the lowermost of the Trap flows. An abandoned well south

of Gurmatkal Travellers' bungalow gives the following section.

Exfoliating Trap.	3 feet.
Drab coloured mud.	2 feet.
Calcareous concentrations.	
Chocolate-coloured mud.	2 ft. 6 in.
Drab mud.	1 foot.
Decomposed gneisses.	24 feet.

Twenty feet of pale yellowish, highly decomposed and jointed pegmatites have been excavated at the bottom of the well without striking water. The rock is fresher at depth but merges into drab calcareous clay about 12″ thick at the top. This is overlain by a well-defined layer, 2′ to 3′ thick, of dark brown (chocolate) clay, which is covered in its turn by 2′ of drab greyish calcareous clay, being separated by a wavy junction from the lower bed. White friable calcareous concretions are interspersed amidst both these layers and are concentrated at the junction. These clays are finally capped by exfoliating trap. Two type samp
the above clay beds give the following analyses :—

	Moisture	Organic matter	CO_2	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Total
Chocolate layer	10.0	6.0	..	60.7	9.5	9.1	2.3	1.9	99.5
Drab layer	8.3	3.6	..	68.0	5.2	10.7	2.0	1.9	99.7

Similar clays, with sometimes red bole-like loose earth, are frequently observed in the Gurmatkal plateau, interbedded between the gneisses and the trap flows. No fossil remains were however observed in them. Stratigraphically these clays probably correspond to the infra-trappean or Lameta beds.

South-east of Hundarki the Deccan Trap rests both on the sandstone and shales of the Lower Bhimas and syenitic gneisses of the Peninsular Complex. At the junction of the syenites and the Trap, exposed along a hill section, there is a white calcareous earth, which is visible from a great distance as a conspicuous white band. Below the white earth fresh undecomposed syenites occur. It is very likely that this calcareous earth is the tufa deposited from the limestones of the Upper Bhimas, and which was later covered over by the Trap.

6. *Deccan Trap.*

The Deccan Traps overlie the gneisses to the east of Long. 77° 16′; to the west of this line they overlie gneisses at some places and at others cap either shales or limestones. On the Sunknur plateau, except for a narrow strip on the west where sandstones outcrop from under the Traps, they directly overlie pink gneisses and syenites. The Deccan Trap outliers in the Ashnal forest likewise cap gneissic hills. To the east and south-east of Hundarki the Traps overlie partly the shales and sandstones of the Lower Bhima series and partly the gneisses. At Allur the limestones are covered by Trap flows.

The Traps lie horizontally over the earlier geological formations. The floor on which the first Trap flow was spread consisted of undulating country of gneisses and Bhimas. The lowermost Trap beds occur at about 2,000′ elevation towards the east and south, and occupy gradually lower levels as we proceed north, and westwards towards the Bhima valley. It may therefore be

inferred that the pre-trappean floor of gneissic and sedimentary formations sloped from south-east to north-west, (*Vide* Plate V).

Gurmatkal plateau.

North of Gurmatkal and partly surrounding it an extensive spread of Deccan Trap flows covers the country and forms a dissected plateau. The basaltic flows directly overlie pink and grey gneisses, though locally exposures of epidiorites and shredded patches of Dharwar schists are seen to underlie the Traps, especially along the southern margin. The Traps here do not stand out in escarpments with a well-defined succession of flows but have occupied and filled up the original undulating gneissic country, and they vary in thickness fromplace to place, (*Vide* Plate V).

Near Gurmatkal, the Traps attain a maximum thickness of 350′, as seen in the table-topped hills north of Yanagundi. The lowermost beds consist of exfoliating boulders weathering to soft greenish earth leaving a hard core in the centre. Along the western margins of the plateau these are about 100′ thick and gradually thin out towards the east.

Inter-trappeans.

This exfoliating Trap is overlain by fossiliferous beds of marl and cherts which are obviously lacustrine in origin and are spread practically over the whole of the plateau. The occurrence of chert beds in the same stratigraphical sequence in the Deccan Trap outliers observed in the vicinity of the main plateau and also beyond the limits of the Trap flows, indicates that the lake in which they were deposited extended much beyond the limits of the present exposures of the Trap. The maximum thickness of these beds is roughly computed to be 50′ and this gives an idea of the time interval which must have elapsed between the effusion of the basal and the next succeeding flow of Trap.

Marls. The marl occurs as horizontal beds of a very soft and friable nature. It is generally pure white but gradations to pale yellow, bluish grey and pink are locally observed. These beds are exposed only in a few natural cuttings and *nala* beds and are not always observed with the associated cherts.

A few type areas may briefly be enumerated here. Half a mile to the west of Gurmatkal, the marls rest directly on the gneisses and are about 6′ thick. Interbedded in these are well-defined layers of drab fibrous limestones markedly resembling woody structure. Another very good exposure of marls is seen about a mile to the west of Kanagadda, in a *nullah* cutting where a section over 16′ thick of white, highly fossiliferous beds occurs. Lenses of dog-tooth spar are seen in profusion at the junction of the marl and the overlying cherts.

The marl exposed half a mile south of Kanagadda is white and massive with stringers of brown calcite crystals freely distributed. Similar exposures are seen a mile to the north-west of Kanagadda and south of Thalmaddi. At the latter place the marl beds contain a pale brown crystalline layer of calcareous siderite. The specimen gives reactions for iron, calcium and perhaps potassium. In the country surrounding Kanagadda crystals of brown translucent calcite with spongy inclusions are strewn locally on the surface.

Cherts. The chert beds which immediately overlie the marls are about 30′ thick, and are very similar in character to the inter-trappean beds described by Bruce Foote* from Shellugi, seven miles north-westof Talikot; except that the occurrence near Gurmatkal is more massive and fossiliferous. Bruce Foote does not mention any fossils. The cherts do not now occur as a bedded

* Mem. G. S. I. Vol. XII, 1876, pp. 198-199.

formation but as large boulders scattered over a thick deposit of black cotton soil, and entirely broken up by atmospheric agencies. Sometimes these boulders have disintegrated into smaller pieces, when the bed is seen as a spread of pebbles and broken bits of chalcedony, chert, etc. The chert is of variable colour from mottled whitish grey to yellowish brown. Some blocks show a more chalcedonic character, with patches of delicate whitish blue or peach colour. The boulders are highly vesicular and very brittle, with sometimes formations of beautiful crystals of quartz in the hollows ; these factors are against their being utilised as a building or decorative stone by any method of cutting or polishing. Dendritic markings of manganese dioxide on the cherts are often observed.

The cherts are overlain by Trap flows which definitely shows them to be of inter-trappean age. They are frequently seen to overlie marls as mentioned above and more frequently still they are observed to directly overlie Traps.

From a field study of these inter-trappean beds the following points emerge. The lower beds consist of calcareous marls and these gradually grade into more siliceous varieties, the cherts constituting the topmost layers. It may be here recalled that in the Deccan Trap amorphous silica such as agates, chalcedony, cherts, *etc.*, occur not only in druses but also as small lenticles. It is generally agreed that these are derived from circulating siliceous solutions which give rise locally to concretions and replacements. By analogy it is assumed that the silica-charged waters percolating through the Traps had a natural outlet at the junction of the hard Traps and the marls, the greatest flow being at the upper junction. It is suggested that such waters have brought about the silicification of the upper layers of marl and for obvious reasons this replacement progressed from above downwards. The well-preserved structures in the silicified

fossils in the cherts further support the suggestion of the metasmotic replacement of the original lacustrine calcareous deposits. The calcite crystals and dog-tooth spar occurring at the junction of the cherts and marls seem to have been derived from such circulating waters.

Fossils

Both the cherts and the marls contain fossil remains of lacustrine origin; the silicified shells in the former have the minute structures well preserved whereas those in the marls are not so clear. The fossils are mostly gastropods and lamellibranches and I have to thank the Geological Survey of India for identifying the following species amongst them.

Paludina decipiens, Oldh.
Lymnæa obtusa, Oldh.
Bullinus prinsepii, Sow.
Oliva. sp. and
Unio.

As these range from Jurassic to Recent it is not possible to fix uniquely the age of the beds, but it may be pointed out that, as the fossil association here is so rich, more intensive work may give us organic remains which may help to form a definite opinion about their age. Remains of some micro-organisms in these beds have been noticed which are receiving attention.

Upper layers of Trap.

The chert bed is overlain by layers of hard Trap capped by laterite. In these upper layers of Trap agates, chalcedony, calcite, and zeolites are frequently developed. To the south-east of hill 2335 and a mile and half north of Kankurti village a well-defined bed of agate about 18″ thick is interbedded with black bouldery Trap, and extends for a few hundred yards. It is however, not possible to define its lateral limits as it is covered by soil and rocks. It consists of alternate grey and white bands

with occasional development of quartz in small druses and sometimes showing red and green staining on the surface, the latter probably due to glauconite. The agate is capable of being cut and polished into decorative articles.

Trap outliers.

To the west of the Gurmatkal plateau a few outliers of Deccan Trap flows cover mostly gneissic hills such as those in the Ashnal forest area. The largest of these outliers forms a plateau surrounding Sunknur and overlies the gneisses except for a small distance on the western escarpment where the Lower Bhima formations are seen to underlie the Trap.

East of Hundarki and north of Allur the Deccan Traps cover the sedimentaries and attain a thickness of about 100′, whereas on the Sunknur plateau they are 200′ thick. On account of the absence of natural cuttings and the escarpments being covered by talus, the sequence of the flows could not be studied in detail.

7. *Laterite and Soil.*

Laterite.

The Deccan Trap on the Gurmatkal Plateau is capped by lateritic layers which occur as table-topped hills, rising as much as 120′ above the surrounding flat country of hard Trap. They form conspicuous landmarks as may be seen north of Yanagundi, near Chapatla, and at Pirlaghat, hill 2256. Red lateritic soil with nodular concretions is spread for considerable distances, round the hills. In some places, as at Pirlaghat, lenses of jasperoid laterite with smooth surfaces are met with. The hills have a flat capping of hard vesicular laterite, about 15′ thick, underlain by softer earthy yellowish red lithomargic clay which is sometimes as much as 100′ thick. The laterites are derived from the decomposition of the Trap, and are for the most part *in situ* deposits.

Soil.

The gneissic area to the south is covered by sandy soil grading into loam. Rich black cotton soil is spread over the north-eastern part of the Gurmatkal plateau, and to the west of it is red lateritic soil. The northern and north-eastern part of the area is covered by black cotton soil and loamy soil. Black cotton soil also occurs fringing the river Bhima.

An oval spread of pebbles occurs between the villages of Kankal, Siddapur, Yalar and Yelsetti. The soil is black loam and the surface is strewn with pebbles of quartz, quartzite, a few gneissic and doleritic pieces, and also occasionally angular pieces of siliceous hornblende-schist. The pebbles are mostly sub-angular and little waterworn, and vary in size from about an inch to 6″ in diameter, but the smaller ones predominate. In the absence of any field evidence it seems far-fetched to invoke the agency of the Bhima river, which flows about 12 miles to the west of this pebble spread, to account for its occurrence. The *nalas* flowing close to it are not of a magnitude to have brought down such large pebbles and spread them over such a wide area. These are probably similar in origin to the pre-trappean pebble beds described by Bruce Foote in the South Maratha country.*

Economics.

Soapstone.

A small outcrop of Dharwar rocks two miles north of Malkapalli has altered into soapstone and forms a hill about half a mile long and 200 yards wide. On this hill are strewn broken and half-made pieces of potstone ware rudely worked out of the soft rock. The rock forms a suitable material for soapstone ware, and the broken and half-made pieces point to the former existence of such an industry.

* Bruce Foote, Mem. G. S. I. Vol. XII, 1876 pp. 168-169.

Building stones.

In the gneissic country, besides the excellent building material obtainable from the hills such as have been utilised in the construction of Yadgir Fort, decorative red syenites and pink porphyries are also obtainable. Fine-grained syenitic gneisses of a pleasing red colour occurring three miles south-west of Narayanpet can be exploited as decorative stones.

The Bhima limestones contain some good beds which yield excellent grey and bluish slabs for flooring purposes. These are quarried north of Allur and at Nalwar and can supply the markets to the south if properly exploited. Yellow limestone, more massive in character, occurs at Turnur, on the banks of the Bhima south-west of Nalwar, and can be utilised as a decorative stone.

Salt.

The thick saline efflorescence which cover the *nala* beds in the sandy country to the south is the raw material for a few salt works. They are capable of obtaining a much larger output than is at present got by primitive and wasteful methods of the local people. The efflorescence is rich in sodium carbonate and bicarbonate which can be recovered by fractional crystallisation and utilised in the glass industry, for which the veins of milk-white quartz afford abundant raw material.

Glass Industry.

When the Yadgir-Gurmatkal road, which is under construction, is completed it will pass through Arkeri and the quartz veins in its vicinity may acquire a commercial importance, especially as this is about the nearest vein quartz deposit to Poona and Bombay. Though the quartz here is iron-stained on the surface it is possible to get better qualities by hand-picking.

The extensive spread of sand, south of the Yadgir-Narayanpet line, with the associated saline efflorescence may afford material for the glass industry.

Agates and ochre.

In the Deccan Traps, agates are found north-east of Yanagundi which although of dull white and grey colours are still capable of being cut and polished into ornamental work. The possibility of locating high-grade ochre by detailed prospecting in the lateritic beds of the Gurmatkal plateau is worthy of investigation.

Archæology.

The only noteworthy archæological find was a rock painting in the hills at Balchakar. On one of the hills, to the south-east, the mural jointings give some very steep straight vertical faces to the huge boulders which appear piled up one above the other. On one of the sides facing west is a panel 15′×10′ of rock painting, in an ochre red colour. The painting consists of representation of animals (bulls, deer, boars, etc.,) and human beings, together with some curious symbols, (*Vide* Plate XI, photo 2).

To the south of the hill by the side of the cart-track is what looks like a dolmen. Three gneissic slabs placed vertically and at right angles to one another support another large one which forms the roof or cap stone. It is open to the north and the slab to the south has a circular hole in the top eastern corner. Approximate dimension of the slabs are 12′×8′.

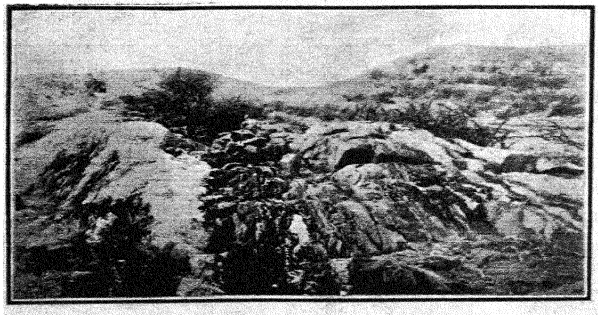


PHOTO 1.—Pegmatite lenses (white) in hornblende schists (black), Nagnur-Godgira track, Surapur Taluq.

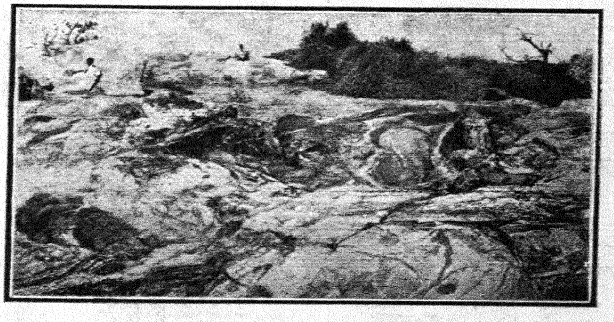


PHOTO 2.—Acidic veins (white) in brecciated hornblendic schists (black) showing assimilation and flow structure. Wandrug Fort, Surapur Taluq.



PHOTO 3.—Porphyritic granitoid gneissic rock showing formation of erosion hollows due to weathering and removal of zenoliths, Kundapur, Mahbubnagar District.

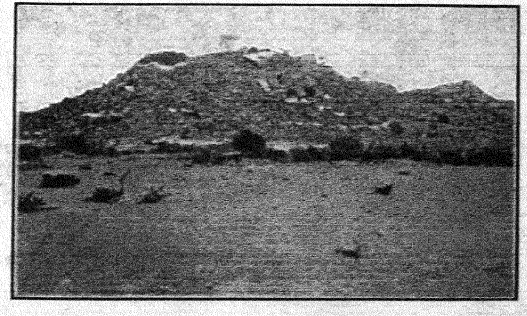


PHOTO 4.—Hill Fort, Koilkonda, Mahbubnagar District, showing characteristic tor weathering of the granitoid gneiss.



PHOTO 1.—Jointed weathering of grey gneisses near Bevanhal, Surapur Taluq.

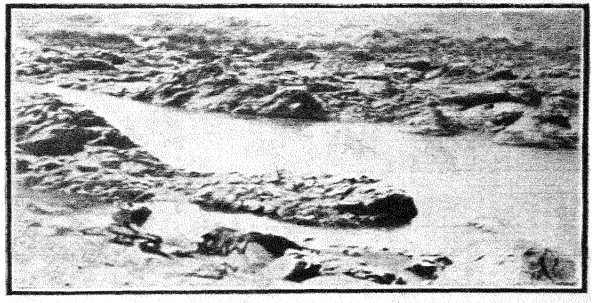


PHOTO 2.—Islands of red syenite and porphyritic gneiss in the Kistna river, Jaldrug, Surapur Taluq.

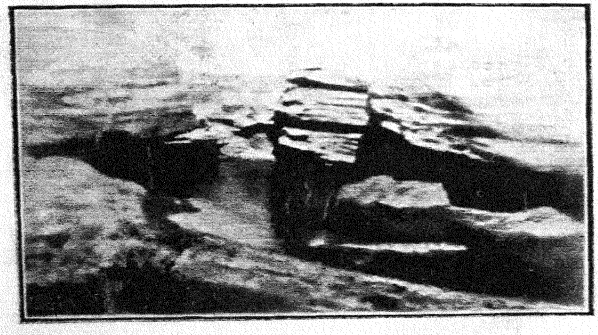


PHOTO 3.—Sandstones in Bachimatti nullah near Hebal Khurd, Surapur Taluq.

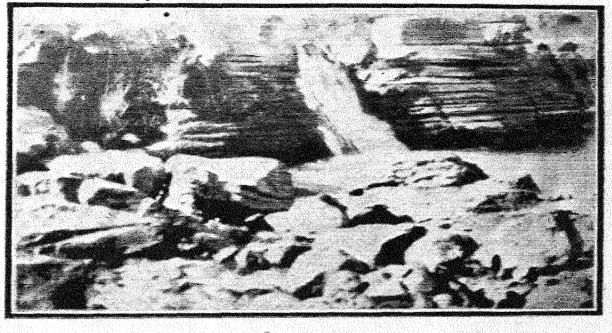


PHOTO 4.—Chennur waterfall, Hunsgi nullah, Surapur Taluq.

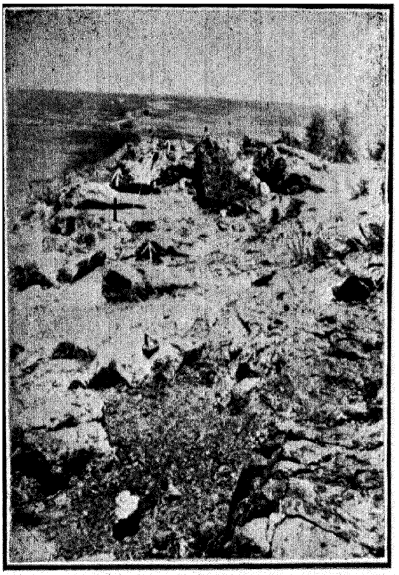


PHOTO 1.—Mottled pink and white quartzite (right side of photo) and quartz vein (left side of the photo) with specular iron ore, Hill.1621, Malla Buzurg-Nagnur track, Surapur Taluq.



PHOTO 2.—Auriferous blue quartz vein (marked B.Q.) passing to pegmatites (towards the rear marked by a hollow in the background), Manglur band, Surapur Taluq.



PHOTO 3.—Narrow dyke, cutting gneissic hill.1555 at 91/4 mile stone, Hyderabad-Krishna Road.

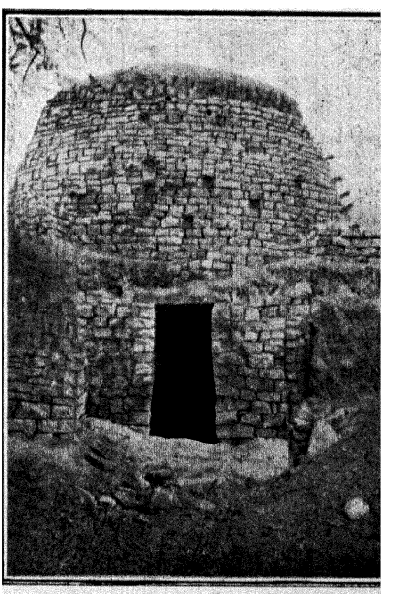


PHOTO 4.—Glass-smelting furnace, Manikonda, Mahbubnagar District.

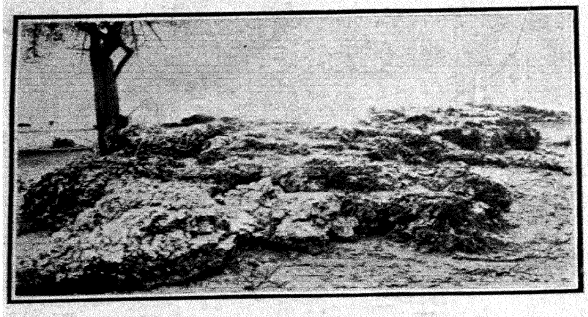


PHOTO 1.—Remnant of an ash mound, on the track from Halisugur to Benkanhalli, Surapur Taluq.

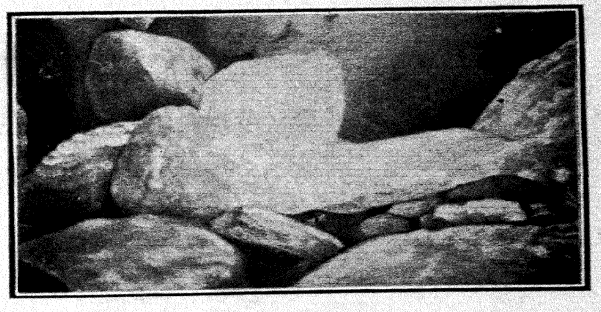


PHOTO 2.—Stone age bell. Kupgal, Surapur Taluq.

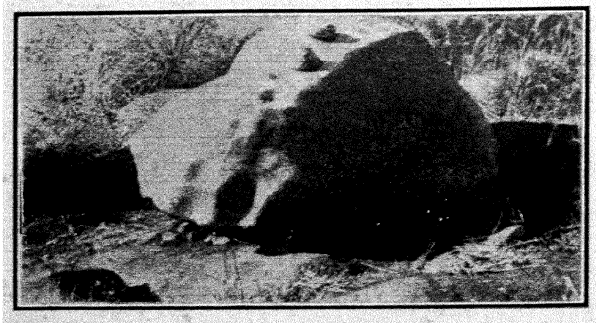


PHOTO 3.—Stone age gong at Devapur, Surapur Taluq.

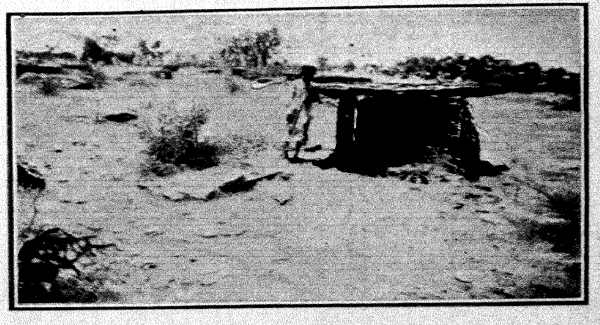


PHOTO 4.—Dolmen, Rajan Kollur, Surapur Taluq.

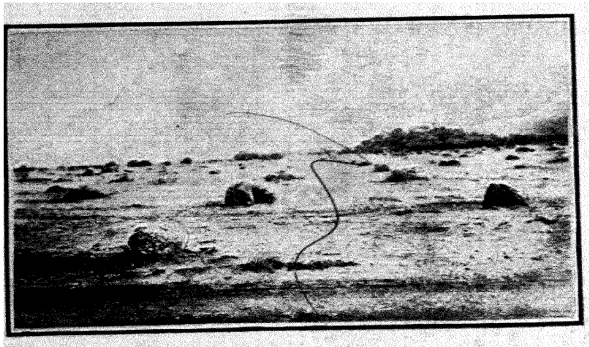


PHOTO 1.—Stone alignment, Vibhutihalli, Surapur Taluq.

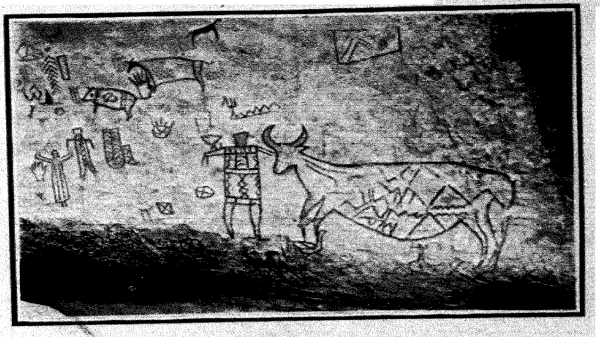


PHOTO 2.—Rock paintings, Balchakar, Yadgir Taluq.



PHOTO 3.—Limestones showing high dip, east of Hunsgi, Surapur Taluq.