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DEPARTMENT OF MINES & GEOLOGY

MYSORE STATE

MINERAL RESOURCES OF MYSORE

A BRIEF ACCOUNT OF THE MORE IMPORTANT ECONOMIC MINERALS, THEIR OCCURRENCE AND DISTRIBUTION WITH NOTES ON THEIR MINING AND METALLURGICAL TREATMENT AND USES.

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Mineral Resources of Mysore.

Introductory.

THE following brief account of the more important economic minerals of Mysore has been compiled at the request of the Government of Mysore for a brief bulletin giving an account of the occurrence and distribution of the minerals of the State, their geological relationship, mining and metallurgical treatment and possibilities of exploitation and use. It is intended that the bulletin shall be translated into Kanarese so that all classes of the community may have an opportunity of taking an interest in the minerals and their development. It has been a matter of considerable perplexity to decide what should be included and what omitted and every effort has been made to keep the bulletin as brief as possible, without omitting features of importance, and to avoid unnecessary technicalities.

A special map has been prepared and included in which the two main rock systems, *viz.*, the Dharwar Schists and the Granitic Gneisses are shown. The distribution of the various minerals is indicated by symbols at points where they have been worked recently or where old workings occur or where noticeable quantities have been discovered.

For those who wish to have further information about the formations a geological map, on a scale of 8 miles to an inch, has been prepared and will be issued separately showing the distribution and relationships of the principal rock types and formations as disclosed by the Geological Survey.

A brief bulletin (Bulletin No. 6) giving an outline of the geological history of the State is in the press and will issue shortly. This may be referred to in explanation of the map or in connection with geological features alluded to in the present publication in connection with the occurrence and distribution of minerals.

With regard to metallurgical treatment it may be noted that the only metallurgical work in the State is the treatment of the gold ores of the Kolar Field with the exception, perhaps, of the now practically extinct local iron-smelting and steel-making industry. It is not possible, therefore, to give specific accounts, based on actual practice and results, of the treatment of other ores and minerals under local conditions. The problem of utilizing local ores and minerals and developing metallurgical industries is however a fascinating one and has been, from time to time, the subject of much discussion and attention and it has been thought desirable, for the information of the public, to give brief notes of processes, uses, etc., of such of the minerals as appear to provide near or remote possibilities of development under local conditions. Such notes, which include in some cases provisional estimates of costs, must be accepted with due caution and reserve. They are based on experience derived from other countries in which many of the conditions are different and although attempts have been made to allow for local factors so far as they are known or can be foreseen it must not be forgotten that commercial success depends on a multitude of adjustments some of which are of considerable delicacy.

It is hoped however that the notes given will be both interesting and useful and will help towards a clearer understanding and discussion of the problems involved.

The minerals dealt with vary greatly in quantity and commercial value and some are little more than specimens of scientific interest. They may be divided into groups as follows:—

I. *Metalliferous minerals.*—Ores of gold, silver, iron, manganese, chromium, copper, lead and antimony.

II. *Minerals used in various industries* :—

(*a*) ABRASIVE MATERIALS.—Corundum, garnet and mill-stones.

(*b*) REFRACTORY MATERIALS.—Mica, asbestos, pot-stone, magnesite, chrome-iron ore and fire clay.

(*c*) MINERAL PIGMENTS.—Red and yellow ochres.

(*d*) MATERIALS USED FOR AGRICULTURE, CHEMICAL INDUSTRIES AND FOOD.—Including lime, apatite, pyrites, earth-salt and earth-soda.

III. *Materials for construction, etc.*—Lime-kankar, lime-stone, brick and tile and pottery clays, kaolin, felspar, building and ornamental stones.

IV. *Rare minerals and minerals of limited occurrence.*—Including monazite, columbite, samarskite, beryl, and graphite.

I. Metalliferous Minerals.

Gold.

Gold is the most important mineral product of the Mysore State and in point of value the produce of the Mysore Gold Mines stands second amongst the minerals of the Indian Empire being surpassed only by coal the total value of which is now rather more than 1½ times the value of the gold from the Kolar Gold Field.

In 1914 the total value of the minerals of India for which returns are available amounted to about 15 crores of rupees (£10,000,000) out of which the gold from Mysore contributed Rs. 3,25,36,710 (£2,169,114) or nearly 22 per cent of the total value of Indian minerals. Since the commencement of modern mining operations in 1882 to the end of 1914 the total gold production of Mysore has been a little over Rs. 63½ *crores (£42,466,790) the whole of which has come from the Kolar Gold Field with the exception of Rs. 43,170 obtained from trial crushings from a few outside mines. In a later section the yearly production is shown in tabular form and a diagram is given showing the yearly progress of the principal mines from the commencement of operations.*

Old workings.—Gold mining is by no means a new industry in Mysore. Hundreds of old workings have been found and bear witness to a widely extended industry in ancient times. There is little historical or traditional information about these workings or the people who made them. Doubtless some are very ancient, while others are of no great antiquity and the rate of gold production must have been quite small. The total amount of gold obtained was no doubt considerable, but even this was in all probability but a fraction of the amount since obtained from the Kolar Mines and is unlikely to have exceeded a few million pounds sterling or a few crores of rupees.

The distribution of the principal old workings is shown on the accompanying map in which the symbol for gold represents in most cases an old working or a group of workings. It will be seen that the workings are confined to the belts and patches of the Dharwar Schists and that they are absent from the great mass of the later intrusive granites and gneisses. It would lengthen this bulletin too much to give a detailed list of these workings, but the more important will be referred to in connection with their geological occurrence and with brief accounts of the work done in investigating them.

General character.

Many old workings still remain as large open pits or as irregular adits, tunnels or burrows. Some have been more or less filled in by natural collapse or by the washing in of debris, soil, etc., and in many cases the filling has been so complete that little or no indications of old workings remain. On the Kolar Field some of these workings extend to a depth of 300 feet and at Hutti, in the Nizam's Dominions, they are said to reach a depth of some

640 feet. The majority are however much shallower and many are mere surface excavations. Dumps of broken rock and quartz are generally found close by and sometimes give a clue to the presence of the workings when the pits themselves have been completely filled in and covered with soil and vegetation.

Value of old workings as indicators.

Ancient workings for gold are no doubt a valuable indication of the presence of gold and of the existence, at one time, of small or large patches of valuable gold ore. It is possible that, as the richer patches were worked out or abandoned, workings were opened on comparatively poor ore which would not even pay under modern conditions; but on the whole it is probable that most workings were on comparatively rich ore. The enormous amount of modern work which has been done on these old workings has proved conclusively that in the majority of instances they do not indicate the existence of valuable deposits immediately beneath them. The mines on the Champion Lode at Kolar, the Hutti Mine in the Nizam's Dominion and one or two mines on the Anantapur Field are exceptions which prove the rule out of a large number of workings below which the absence of valuable deposits has been practically ascertained. The old workings on the Champion Lode at Kolar followed each other in close succession for four or five miles along a well-defined line and were excavated on a number of rich shoots in the quartz vein, or succession of veins, which carry the gold. The shoots are sufficiently large or sufficiently numerous to permit of new ones being searched for and opened up before the earlier found ones are exhausted and the fact that they are mostly distributed along a nearly continuous vein of quartz or lode matter facilitates and directs the search. The numerous old workings along a line at surface is an indication of these favourable conditions. Elsewhere in the Kolar Gold Field and in other parts of Mysore these conditions do not exist to anything like the same extent, but hundreds of old workings exist which are isolated or in irregular groups and which indicate the former existence of small isolated lenses or shoots of rich ore, or rich pockets in low grade zones or superficial accumulations of the weathered, and possibly enriched, debris of low grade veins or lode matter. The sanguine hopes which have been entertained about these workings, many of which are of considerable size and depth, have not been realized notwithstanding the large amount of work and money expended. The amount of money expended on the prospecting of these old workings in Mysore—outside of the Kolar Gold Field—is in the neighbourhood of 30 to 40 lakhs of rupees and so far not a single paying mine has been discovered.

Quartz outcrops valueless.

Numerous quartz veins traverse the schists and many of them outcrop at surface. Some of these outcrops are close to old workings and in the early days of prospecting were regarded as valuable indications of gold. Since then a large number of these outcrops have been tested and in many places trenches and shafts have opened them up and have demonstrated their valueless character. Occasionally assays of a few dwts. have been obtained and in two instances in the neighbourhood of Kudrikonda small outcrops of quartz have been found recently from which assays of some ounces per ton were obtained. We may take it as an almost universal rule that outcropping veins are valueless. The systematic search for gold by the ancient workers as revealed by old workings has resulted in the almost complete removal of outcrops carrying valuable amounts of gold and in the majority of cases these shoots or pockets have been completely cleaned out. There is no doubt that other shoots, lenses and pockets occur at varying depths below surface and give no surface indications of their existence. Many of these have been opened up in the course of deep prospecting, but with the exception of those on the Kolar Field all have proved to be small and erratically distributed rendering the cost of prospecting and mining greater than the value of the gold recoverable.

These conditions render the work of the prospector difficult and very expensive, and the results obtained so far are most discouraging and disappointing. There are a few points at which further work is expected to be carried on after the war and it is possible that some zones of low grade lode matter may be found of sufficient extent and under sufficiently favourable conditions for cheap treatment to permit of their being worked, but we cannot shut our eyes to the fact that the hopes based on the success of the Kolar Mines and on the existence of numerous old workings in other parts of the State have dwindled very seriously with the progress of survey work and deep prospecting.

A very brief account of the distribution of the gold in the various geological formations and of the results of modern prospecting work at the more important points will now be given. A brief account of the formations will be found in Bulletin No. 6 and they will not be described in any detail here. Further details of the work done will be found in the Reports of the Chief Inspector of Mines and in the Records of the Geological Department the summarized contents of which will be found at the end of this Bulletin.

The older known workings have been described by Bruce Foote in his "Auriferous Tracts in Mysore" (1887), extracts from which will be found in Rice's Gazetteer of Mysore, Volume I, 1897. At the time that the Kolar Gold Field was beginning to attract attention leases were taken out over the majority of these old workings, but the work done failed to yield promising results and there was a lull in prospecting work. Subsequently, as the results of the work of the Geological Survey, many old workings, not hitherto known, were discovered and for the past ten or twelve years there has been a considerable renewal of activity the results of which have been, so far, disappointing on the whole.

GEOLOGICAL OCCURRENCE OF GOLD.

The gold occurs chiefly in quartz veins and lenses in the Dharwar Schists both in the *lower division* consisting of dark hornblendic schists and amphibolites and in the *upper division* consisting of greenstones, chlorite schists, calc-chlorite and talcose schists. The former are the most important and include all the mines of the Kolar Field and the Hutti Mine in the Nizam's Dominions which are the principal producers in India. As the two divisions of the schists are not differentiated in the accompanying map the various old workings and places where gold has been found or worked are distinguished by different symbols according to whether they lie in the lower or the upper division. The auriferous veins of the Kolar Field are mainly of a dark bluish or grey colour, but the colour varies greatly and is often nearly white. On this account dark blue veins are usually regarded by prospectors as a favourable indication of gold, but this is by no means a satisfactory guide. Veins of very dark quartz occur in both the hornblendic and chloritic rocks and commonly carry no gold. On the other hand many small rich lenses and stringers of white quartz have been found during prospecting work especially in the chloritic schists. In the Dharwar (Gadag) Field which lies on the northern extension of the Chitaldrug belt practically all of the old workings are in white quartz veins in the chloritic series and the same is believed to be the case on the Anantapur Field. On the other hand the auriferous veins of Kolar and Hutti are of the dark blue variety and lie in the dark hornblendic rocks.

On the whole it is probably a fair generalization to say that the auriferous veins of the lower (hornblendic series) are usually dark, while those of the upper (chloritic) series are usually white or nearly so. In addition there are other veins of dark quartz in both series which are barren and are probably of a different age to the auriferous ones and there are numerous and very conspicuous veins of white quartz in both series and in the gneiss which are also barren and are probably of later age than the auriferous veins as a whole.

Maclaren [1] has noted the above distinction between the

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[1] Notes on Some Auriferous Tracts in Southern India. By T. Malcolm Maclaren, B.SC., F.G.S., Records, Geological Survey of India, Volume XXXIV, Part 2.

auriferous veins of the chloritic and hornblendic rocks and suggests that those of the hornblendic series are much older than those of the chloritic series which latter he conceives to be associated with the great igneous activity represented by the numerous dolerite dykes which traverse the schists and gneisses and therefore of post-archæan age. We are unable to agree with this latter suggestion. It may be true that the dark veins in the hornblendic rocks are older and more crushed than the white veins of the chloritic series, but even this is by no means certain. The degree of crushing is locally very variable in both cases and some of the white veins show considerable signs of crushing and movement and appear to be older than many of the barren veins of quartz and pegmatite which occur in the schists and gneisses and which are intruded by the dolerite dykes. The latter show no signs of crushing or movement whatever. It must be remembered that Maclaren regarded the schists as laid down on, and later than, the fundamental gneiss and was therefore debarred from regarding the latter as a source of the quartz and gold. We take the opposite view as explained in the following section.

ASSOCIATION OF AURIFEROUS VEINS WITH ACID INTRUSIVES.

In Mysore the evidence that the fundamental gneiss—or as we now prefer to call it the Peninsular gneiss—is younger than the Dharwar Schists is so strong that it may now be regarded as established. Further, we have shown that there is a limited gneissic series—the Champion gneiss—which is older than the Peninsular gneiss but still younger than the Dharwar Schists and we regard this Champion gneiss as responsible for the auriferous veins—at any rate for those of the Kolar Field. For this reason the main exposures of the Champion gneiss and its associates have been shown on the map although there may be considerable doubt about the correlation of several of the patches shown. Briefly this old gneiss is a complex of various granites, micro-granites, aplites and pegmatites usually highly crushed and often characterised by blebs of a milky to dark blue quartz. It tends to pass into finer forms of felsite and quartz-porphyry and isolated exposures of these finer forms as well as some alaskites and finely granular or crushed quartzites are provisionally correlated with it.

The auriferous veins of the Kolar Field are intrusive into the schists and produce contact metamorphic effects which are strikingly similar to those produced by the gneisses, granites and pegmatites (1) and strongly support the view that the auriferous veins are igneous in origin and to be regarded as one of the end-products of a granitic intrusion. Tongues of micro-granite which are regarded as belonging to the Champion gneiss come into the Mysore Mine in close proximity to the Champion Lode and the quartz of the latter has been observed to penetrate these tongues.

On the other hand the great mass of the Peninsular gneiss cuts off both the auriferous schists and the Champion gneiss while the pegmatite veins and cross-courses which cut the Champion Lode are probably products of the intrusion of the Peninsular gneiss. The auriferous veins of Kolar appear therefore to be subsequent to the Champion gneiss and prior to the Peninsular gneiss (or some of it) and in seeking a granitic origin for the gold bearing veins the Champion gneiss appears to offer a handy and suitable source.

Whether we can accept a similar source for the white veins of the chloritic series—the differences in colour, form and degree of crushing being due to the nature of the enclosing rock—is debatable, but it may be noted that recent survey work has been extending our knowledge of the Champion gneiss and that intrusions of it or its associates are now considered to exist in the neighbourhood of the Honnali Field and of the great series of old workings extending from Honnegudda round the south of the Tarikere gneiss to Nandi and across the valley to Ajjampur. In connection with this some work done by Mr. Bosworth Smith during the past two years on the

(1) The occurrence of Secondary Augite in the Kolar Schists. By W. F. Smeeth, M.A., D.SC., etc., Mysore Geological Department, Bulletin No. 3.

Honnali Field is of great interest. Gold is widely spread in the soil and nullas of that area and examination of a large number of washings led Mr. Bosworth Smith to the conclusion that it was not uniformly distributed but tended to come from certain lines or zones where acid intrusives occurred in the chloritic schists and greenstones. These acid intrusives have been considered by us as probably belonging to the Champion gneiss without our being aware of Mr. Bosworth Smith's conclusions or he of our views and the evidence from the two points of view is independent. No results have been obtained yet but the work will be continued after the war and may prove interesting, not perhaps in the way of disclosing rich ore in any quantity, but possibly in the way of discovering some zones of low grade auriferous lode matter which would permit of cheap working.

There is however ample opportunity for the occurrence of later quartz veins of granitic origin in connection with the intrusions of the various components of the later Peninsular gneiss, to say nothing of possible later or earlier acid relatives of the ultrabasic or other intrusives of the archæan period.

OTHER OCCURRENCES OF GOLD.

In addition to the usual quartz veins in the schists we may refer briefly to various cases in which either the lode material or the enclosing rock presents some special features.

Veins in Trap.

At Bellara in the Tumkur District the old workings and auriferous veins occur in a large mass of trap (hornblende diabase) which is considered to be intrusive into the chloritic series.

At Honmaradi in the north of the Chitaldrug District old workings occur in a grey chloritic trap which has been grouped with the Bellara trap under the name 'Grey Trap,' though it is doubtful whether the former does not belong to the greenstones of the upper division of the Dharwars.

Old workings in Potstone.

At several places old workings occur in the potstone or talc schists which are altered amphibolites and peridotites intrusive into both the upper and lower Dharwars. Amongst these may be mentioned those at *Chornadihalli* near Sakrebail, some of the workings at *Jalagargundi* and a number of workings on the *Devrukal* block near Yedahalli. There is some doubt about these being gold workings and definite auriferous veins have not been found.

Gold in Ferruginous Quartzite.

The great series of banded ferruginous quartzites has been found to carry a little gold in places and a number of small old workings occur along the ridges of these rocks on the western edge of the Kolar Schist belt. These old workings have not been shown on the map as they are not important. Traces of gold may be obtained by sampling and panning but too small to be worth attention. Veins of bluish quartz occur in the rock and sometimes carry a little gold, but the gold appears to occur also in the banded quartzite itself.

Amongst other places which have been examined the following may be mentioned :—

Shaw's Block; just north of the Kolar-Betmangalam road where three runs of ferruginous quartzite belonging to the western side of the Kolar schists were closely prospected with occasional results up to 10 dwts.

Dindivara; about 12 miles north of Bellara where there are some old workings on two runs of this rock which gave from traces up to a few dwts.

Ajjanhalli; some five or six miles east of Dindivara where a mixed series of ferruginous quartzites and veined chloritic schists gave results up to some 8 dwts. A trial crushing of 200 tons of an average assay value of 3·69 dwts. was made at Kolar and gave an extraction of 1·46 dwts. per ton by amalgamation.

Bodimaradi; about 7 miles N.-W. of Marikanave. This is perhaps hardly a case in point as the old working is in soft ferruginous ochres between two runs of ferruginous quartzite. Prospecting work showed some small irregular veins of quartz which gave some good assays and parts of the ferruginous country itself gave 3 to 4 dwts. in patches.

Attention has been called to the occurrence of gold in these ferruginous rocks because there is the possibility that somewhere a sufficiently large mass of auriferous lode matter might be discovered which would pay to work even though the average value did not exceed some 3 to 5 dwts. per ton. The nearest approach to this is the result obtained at Ajjanhalli which was not considered good enough to justify further expenditure.

As an illustration of what can be done the case of the Wanderer Mine in Rhodesia may be quoted. Rhodesia is very similar, geologically, to Mysore, and at the Wanderer there are very large ore-bodies composed partly of these ferruginous quartzites and schists and partly of various talc-chlorite-calc schists associated with conglomeratic material which is probably a crush breccia.

Parts of the ore body were 150 feet wide at surface and very cheap open working was possible. Subsequently underground work has been carried on on lode matter 60 to 70 feet in width and mining costs are still very low. The metallurgical treatment is also exceptionally simple and consists of breaking, coarse crushing by rolls and direct cyanide treatment of the product. Assays up to 10 dwts. are sometimes obtained, but the average value of the lode is said to be from 3 to 4 dwts. (Rs. 9 to 12) per ton and the working costs (mining, crushing and cyaniding) a little over Rs. 5 (6*s.* 9*d.*) per ton. Allowing for other charges the work can be carried on at a small profit. In this case we have a very large body of low grade ore which can be mined cheaply and treated very simply on a large scale, and although we have not yet realized these conditions in Mysore the fact that similar classes of material exist leads one to hope that they may yet be found on a big enough scale to justify work.

Gold in Conglomerate and Quartzite.

In the hornblende schists on the south side of the Bababudans north of Chikmagalur there are long beds or bands of quartzite which we regard as probably intrusive veins or sills. The bottom bed close to the disturbed and faulted junction with the intrusive granite and gneiss has bands of pebbles which may represent zones of crush-breccia. The matrix of the pebbles contains pyrites and is often stained green by copper. Panning showed some gold and a sample of one of the pebbly layers gave an assay of 2 dwts. The extensive exposures and gentle dips as well as the similarity of pebbly portions to such auriferous material as the *banket* of the Transvaal suggested the desirability of further investigation as even a comparatively low grade material would be worth working under these conditions. Large samples were broken from both the pebbly and quartzite bands over several miles of outcrops and a large number of assays made which unfortunately gave no encouraging results. Practically all gave traces of gold and many gave traces of copper also but in no case did the gold amount to 1 dwt. per ton.

Old workings occur in quartzite at *Nandi* south of Tarikere and in the highly quartzose chloritic schists at *Ajjampur* and appear to have been sunk on pipes, pockets or impregnations carrying gold of which no extensions have been found. Below the deepest old working at *Ajjampur* veins of dark blue quartz were found which carried no gold but occasional good assays were obtained from the highly quartzose schists themselves.

At *Jalagargundi*, at a depth of 200 feet an ore body has been opened up which might be regarded as a banded quartzite or quartz-schist carrying calcite, and much pyrites, the banding being marked by brown ferruginous dust. The gold is mostly free and the lode is adjacent to and penetrated by white vein quartz which is barren. The prospects of further work will be referred to later.

Gold in acid intrusives.

There are a few minor old workings in the Champion gneiss itself on the east side of the Kolar Field. At *Ahmed's* Block near Ooregum a shaft in the gneiss showed a small quartz vein 6 inches thick, but pinching to a stringer at a depth of 55 feet, which gave nearly 4 dwts. per ton.

On the *South Amble* Block, S.-W. of Nanjangud some of the patches of schist held veins of alaskite or pegmatite from which occasional assays up to several dwts. were obtained.

At *Kudrikonda* one at least of the old workings appears to have been sunk on or alongside of quartz-porphyry which probably contained a small pocket or shoot of gold though the trial shaft sunk many years ago is believed to have given no results of value.

These cases are quoted in view of the fact that we have been led to associate many of the felsites, quartz-porphyries and alaskites with the old Champion gneiss the connection of which with the auriferous veins of Kolar has been referred to already.

On the other hand we have no evidence that the great mass of the Peninsular gneiss is auriferous nor have old workings been found in it though some occur in mixed bands of gneiss and schist. We cannot however say that some of the auriferous veins and lenses in the schists may not be end-products of some components of the Peninsular gneiss and it is probable on the whole that the auriferous veins are not all of one age.

Gold in soil and alluvium.

Gold is widely distributed in the soils on the various schists or derived from them and in the alluvial materials along water-courses and river valleys which traverse the schists. Washing has been carried on in the past by native Jalagars or gold-washers but very few of these remain and their earnings are very small and uncertain. They seldom make more than a few annas a day with an occasional lucky find. A few years ago a Lambani found a nugget weighing nearly 4½ ozs. somewhere about Kudrikonda or Palavanhalli, but no further finds have been made although a good deal of washing and prospecting has been done in the neighbourhood. Very occasional results of a few dwts. have been obtained; but on any considerable scale the results fall within a few grains per cubic yard and the scarcity of water renders the prospects of work practically hopeless.

Some years ago a series of trial pits and washings were made in the alluvium in the bend of the Bhadra river immediately south of the great series of old workings at Honnehatti. There were rumours of good gold having been found there years before and a good deal of gold must have been weathered out and washed away from the surface deposits on which the old workings were made. The trials were a complete failure, very occasional small shows of gold being obtained.

More recently an extended series of tests have been made by the department on the alluvium in and near the bed of the Tungabhadra river, where it crosses the auriferous schists between Shimoga and Honnali. Previous work had shown that gold was distributed in the soil and along small water-courses and the fact of a large supply of water being available rendered a further investigation desirable.

A couple of washing cradles were made and a large number of pits and trenches dug both in the gravels of the river bed and in the alluvium and soil some distance from the banks. Large samples of from one to six cubic yards each were washed and all showed gold, but the quantity was small in every case. An average of all the tests made gives a result which does not exceed 1 grain per cubic yard and the best result obtained was only $3\frac{1}{4}$ grains per cubic yard. These results are too low to hold out any prospect of profitable working. In the case of the $3\frac{1}{4}$ grains test, the results would be worth following up if the character of the deposit was favourable, but unfortunately this is not the case as the gold occurs in a hard gravel about 1 foot thick fringing the bed of the river and if it extends laterally beneath the river bank some 10 feet or so of hard clay overburden would have to be removed to get at it. Under these circumstances the prospects of work on a large scale cannot be regarded as encouraging though it is difficult to understand why the gold should not occur in more highly concentrated patches of workable extent. Similar results have been obtained elsewhere in India and it has been suggested that the seasonal alternations of heavy rainfall and flood with long spells of dry weather are not favourable to the sorting out and collection of the gold in alluvial deposits for which the more or less regular and long-continued action of running water would appear to be essential.

In the foregoing notes we have endeavoured to summarize very briefly the information acquired so far about the gold of Mysore, the nature of the veins or other lode material which carry the gold and the various formations with which they are associated.

In the next section we propose to refer briefly to the more important work done at various points, the character of the work and prospects.

MINING AND PROSPECTING WORK.

KOLAR GOLD FIELD.

It is not possible to attempt any systematic account of the Kolar Mines within the limits of this pamphlet. A general account of the mines and their working, up to the year 1900, has been given by Dr. F. H. Hatch (1); and a few more recent notes and figures will be added here.

The main Champion Lode runs almost continuously through the Mysore, Champion Reef, Ooregum and Nundydroog Mines. In places the quartz has been 30-40 feet wide but the average of the parts worked is probably between 3 and 4 feet, while in places the lode is represented by mere stringers or veined schists or a mere parting of altered schist or lode matter. The quartz sometimes branches and in several places there are one or occasionally two parallel veins from which a good deal of ore has been obtained. The veins strike more or less north and south, but in Mysore there are marked curvatures. The dip, or inclination from the horizontal, of the veins is to the west and is least in the Mysore Mine, where it is about 45°, and increases as we go northwards to over 60°. These figures refer to the upper portions of the mines, down to a depth of 3,000 feet or so, but in recent years the veins have shown a general tendency to get steeper with increasing depth so that at 4,000 to 5,000 feet on the underlie we get dips of 50°-55° in Mysore and of well over 70° in Champion Reef and Ooregum. There are a few large zig-zags which are usually called "folds" though it is probable that they do not represent the actual folding of a once plane sheet

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(1) The Kolar Gold Field, being a description of Quartz Mining and Gold-recovery as practiced in India. By F. H. Hatch, PH.D., A.M.I.C.E., F.G.S., Memoirs of the Geological Survey of India, Vol. XXXIII, Pt. 1.

or vein of quartz and are more likely due to the filling in of zig-zag or branching fissures or dislocations.

The most important feature is the occurrence of the more valuable portions of the veins in patches or shoots with intervening areas of poor quartz or lode matter, and the success of the Kolar Gold Field is due to the fact that these shoots are of considerable size and value and sufficiently numerous to permit of new discoveries being made before the old ones are exhausted. The steady progress of the mines is due not to uniformity in the veins, as the distribution of the gold is very uneven, but to the very extensive exploratory work which is carried on far below the points where ore is being extracted and which permits of work being planned several years ahead of the milling requirements.

In addition to these features the existence of slides or faults cutting the veins has received much attention in recent years, particularly in Mysore and Champion Reef. The great blank in the Mysore Mine between the Ribblesdale and Tennant Sections is due to a great slide slightly oblique to the lode and complicated by others more oblique and it seems probable that the great Crocker's shoot was terminated at its northern end by these slides and not by the natural dwindling of the shoot.

Life of the Kolar Field.

The Field has already yielded gold to the value of nearly £44,000,000 sterling and the nett annual return to the State from royalties and the sale of electric power and water is in the neighbourhood of 30 lakhs of rupees while the yearly wages bill is over 80 lakhs. The question of the continuance of such an important industry is a serious one which is often raised, but anything in the shape of a very definite pronouncement is out of the question.

The auriferous veins lie in a narrow belt of hornblende schists, of about three miles in width, which is cut off on both sides and below by a later intrusive gneiss. The auriferous veins are believed to be older than the gneiss and will therefore be cut off along with the schists at some depth below surface. This depth represents the ultimate limit of the Kolar Gold Field and we see no reason to apprehend that it will be less than some 10,000 to 15,000 feet from surface and perhaps more. The cut out may of course occur closer to surface, but the above figures are reasonably probable and we need not hunt trouble. The mines have now got down to a depth of rather over 5,000 feet on the inclination of the veins or to a maximum verticle depth of some 4,900 feet from surface. This has taken over 30 years and, if we assume a downward development of 200 feet per annum, we shall have reached a vertical depth of about 8,000 feet in twenty years which is well within the ultimate limit suggested above. It is not improbable that with a low temperature, gradient and efficient ventilation mining can be carried down to 8,000 feet and we need not speculate about greater depths; but it may be noted that down to this depth the whole of the ore will not be worked out in twenty years and that the total period of work will be more probably thirty years. We are assuming, however, that not only do the veins continue, but that the auriferous portions of them or the "shoots" continue to occur with sufficient frequency and of sufficient size to keep up the returns. No one can foresee if this will be so, but, while we see no reason to apprehend any systematic diminution for many years, it would be sound to contemplate reduction of output in the later years.

The problem of the continuance of the Kolar Gold Field is obviously a speculative one and in mining work the more unfavourable contingencies are wont to occur with undue frequency, but we do not see any inherent improbability in assuming that the Kolar Gold Field will continue for another twenty to thirty years, at least, with a probable diminution of output in the later years.

Statistics of production.

In the following tabular statements the yearly output of gold from the Kolar Field is shown from the commencement of operations to the end of 1914. Small amounts obtained from trial crushings at other mines are also shown.

TABLE 1.—*Gold Production and Royalty.*

Year	Kolar Gold Field £ Stg.	Other Mines £ Stg.	Total £ Stg.	Royalty Rupees
1882 ...	38	...	38	...
1883 ...	96	439	535	330
1884 ...	4,430	332	4,762	3,540
1885 ...	23,989	871	24,860	18,465
1886 ...	63,027	...	63,027	46,785
1887 ...	57,028	...	57,028	42,255
1888 ...	128,879	...	128,879	95,880
1889 ...	298,861	...	298,861	2,22,705
1890 ...	409,449	77	409,526	3,04,620
1891 ...	504,324	...	504,324	3,75,150
1892 ...	622,159	...	622,159	4,62,660
1893 ...	784,842	...	784,842	5,82,810
1894 ...	795,156	...	795,156	5,90,430
1895 ...	973,610	...	973,610	7.23,240
1896 ...	1,228,665	379	1,229,044	9,12,330
1897 ...	1,487,140	92	1,487,232	11,06,790
1898 ...	1,575,966	...	1,575,966	11,70,135
1899 ...	1,678,464	...	1,678,464	12,47,310
1900 ...	1,879,086	...	1,879,086	13,99,980
1901 ...	1,923,130	...	1,923,130	14,28,780
1902 ...	1,964,509	...	1,964,509	14,58,810
1903 ...	2,284,071	...	2,284,071	16,97,085
1904 ...	2,323,195	...	2,323,195	17,26,200
1905 ...	2,373,458	...	2,373,458	17,56,245
1906 ...	2,167,637	324	2,167,961	16,11,390
1907 ...	2,049,064	206	2,049,370	14,96,925
1908 ...	2,055,887	66	2,055,953	15,21,660

TABLE 1—*concld.*

Year		Kolar Gold Field £ Stg.	Other Mines £ Stg.	Total £ Stg.	Royalty Rupees
1909	...	2,092,459	92	2,092,551	15,49,470
1910	...	2,107,749	...	2,107,749	17,67,045
1911	...	2,129,878	...	2,129,878	18,58,845
1912	...	2,158,362	...	2,158,362	18,85,835
1913	...	2,150,195	...	2,150,195	18,78,870
1914	...	2,169,114	...	2,169,114	18,69,480
Total	...	42,463,912	2,878	42,466,790	3,28,11,555

A statement showing the total production from each mine is also given and from the 'Remarks' column it will be seen that most of the less productive mines, which have ceased independent work, have been incorporated with the present working Companies.

TABLE 2—*Total Gold Production of Mines in Mysore, to end of 1914.*

Name of Mine	Bar gold oz.	Value £ Stg.	Remarks
A—Kolar Gold Field—Mines approximately in order from north to south.			
Road Block ...	1,996	7,703	Produced gold during 1898-1901. Included in the Balaghat Block since 1910.
Nine Reefs ...	21,357	92,356	Produced gold during 1887-1890 and 1894-1902. Now included in the Balaghat Block since 1910.
Balaghat ...	433,283	1,642,331	
The Gold Fields of Mysore. ('Golconda' and 'West Balaghat' Mines).	9,496	33,528	Ceased producing gold in 1909. The Company however is in existence.
Coromandel ...	52.940	195,701	Produced gold during 1895-1907. Now included in the Balaghat Block since 1910.
Tank Block ...	117,757	122,870	Produced gold during 1893-1910. The block is included in the Nundydroog Block.
Oriental ...	925	3,526	Produced gold in the years 1901 and 1904 only. Now included in the Nundydroog and Ooregum Blocks since 1910.
Nunydroog ...	1,494,058	5,579,886	
Ooregum ...	1,911,077	7,006,686	
Mysore... ...	4,162,592	16,182,740	
Champion Reefs ...	3,011,674	11,292,209	
South-East Mysore	411	1,303	Originally part of Simons Block known as Rodger's Camp. Now part of the Mysore Block. Produced gold during 1888-1890.
Mysore Reefs ..	699	2,468	Years of gold production were 1889-1891. Now styled 'South Mysore' and is held by the Mysore Gold Mining Co. (1910).
Yerrakonda ...	192	602	Produced gold in 1894-1896. The lease is current and is held by the Indian Mines Development Syndicate.
Total ...	11,251,457	42,463,912	

TABLE 2—*concld.*

Name of Mine	Bar gold oz.	Value £ Stg.	Remarks
B—Mines outside the Kolar Field.			
Ajjanhalli (Sira Taluk) ...	18	66	Trial crushings in 1908. Abandoned.
Mysore Haranhalli Gold Mine ...	25	77	Trial crushings in 1890. Abandoned.
Kempinkote, Hassan District ...	45	164	Trial crushings in 1896. Abandoned.
Woollagiri Block, Nanjangud Gold Field	203	622	Produced gold during 1906-1909. Abandoned.
Honnali Gold Mining Co. ...	528	1,642	Produced gold during 1883-1885. Abandoned.
Honnali Tribute Syndicate ...	100	307	Produced gold 1896-1897. Abandoned.
Total ...	919	2,878	
Grand Total ...	11,255,376	42,466,790	

A diagram is furnished which shows at a glance the progress of the principal producing mines and of the Kolar Field as a whole. For convenience of space the curve of total production is drawn on half the scale used for the individual mines.

Mining.

For a general account of the methods of mining reference may be made to Hatch's Memoir already cited. As the mines have got deeper, the incline shafts, which followed the trend of the veins downwards, have reached the limits at which it is safe or convenient to use them for hoisting ore for the transport of men and materials. The deepest of these is Carmichael's Shaft, Champion Reef, which is 4,700 feet long. To facilitate work in the deeper levels several vertical shafts have been sunk during the past ten years or so to the west of the outcrop of the lode, of which the principal are the following :—

Edgar's Shaft, Mysore Mine. A circular brick-lined shaft which intersects the lode at a vertical depth of 2,600 feet.

Gifford's Shaft, Champion Reef. Also circular and brick-lined. It is 3,800 feet deep and now practically ready for use. The lode, which has got steeper lies a little to the east of the bottom.

Bullen's Shaft, Ooregum. A rectangular, timbered shaft completed in 1910 to a depth of 3,760 feet. Passed through the lode near the bottom.

Preparations are now being made for continuing work to a much greater depth to provide for which the following shafts have been started recently, all of which will be circular and brick-lined.

MacTaggart's, at the southern end of the Mysore Mine.

Edgar's, Mysore Mine, which is now being deepened to 4,000 feet.

New vertical, Ooregum.

New vertical, Nundydroog.

These shafts will all be about 4,000 feet deep and take some six or seven years to complete. From near the bottom of each, secondary shafts will then be sunk from 4,000 to 7,000 feet or more. The working at these depths will naturally be very hot and much artificial ventilation will be needed. There is no reason to think that work cannot be carried on in these mines to a depth of 7,000 feet or more, and as already pointed out, we see no reason to apprehend any serious failure of the auriferous shoots.

Metallurgical treatment.

More detailed notes on the treatment of the ore for extraction of the gold will be found in Hatch's Memoir (*Op. cit*) and in the Reports of the Chief Inspector of Mines in Mysore for the years 1903-04 and 1911-12.

The practice now followed may be summarized very briefly as follows :—

Sorting and breaking.—The ore is raised to surface and screened to separate the fines from the larger lumps. The latter are crushed in rock breakers to the size of road metal and any pieces of waste rock picked out and discarded. About 18 per cent of the total ore raised is thus rejected.

The ore (fines and coarse) then goes to the stamp mills where it is pounded with water to a fine sand. The fine sand and water is forced by the splash of the stamps through wire screens (900-1200 holes to the square inch) and flows over sloping tables covered with sheet copper on which mercury is spread in a thin layer. The fine particles of gold adhere to the mercury and form with it an amalgam of gold and mercury. The amalgam is scraped from the plates at regular intervals and folded up in a piece of wash-leather in which it is subjected to squeezing. During this squeezing the excess of mercury is forced out through the pores of the leather leaving a hard ball of amalgam inside which contains 40-50 per cent of gold. The balls of amalgam are heated in retorts and this drives off the remaining mercury, leaving a porous mass of 'sponge' gold behind. The sponge gold is melted in crucibles and poured into moulds thus forming 'bar' gold which is sent to England and refined to get rid of impurities.

Cyanide treatment.—The greater part of the gold is removed by the amalgamating tables, but the fine sands (or tailings as they are called) flowing from the tables still contain some gold (about 3 dwts. per ton) which has not been caught by the mercury. The sands are therefore treated with cyanide of potassium which dissolves the gold; and the gold, or most of it, is recovered from the solution.

The treatment as practiced at present may be roughly outlined as follows:—

The tailings from the stamp mill are put through a series of hydraulic separators and classifiers by means of which they are divided into three grades according to fineness, *viz*:—

(1) Impalpably fine slimes;
(2) Fine sand;
(3) Coarse sand.

The coarse sand is put through revolving tube-mills which grind it finer after which it goes back to the separator where it is divided into slimes and fine sands. The process of separation and classification is a continuous one and the final result is that the tailings are divided into two portions one of which is "fine sand" and the other "slimes" which are treated in separate plants.

Fines and treatment.—The fine sand is placed in large vats each holding one or two hundred tons. The bottom of the vat is formed of canvas filter cloth suitably supported. When the vat is full of sand, cyanide solution is poured in and allowed to stand. The gold is gradually dissolved and when this is complete the solution is drawn off through the filter bottom and water run in to wash out all the gold solution from the sand. The sand is removed from the vat and thrown on the waste dumps.

The gold-bearing solutions are passed through long boxes in which there are a number of compartments filled with zinc shavings. The zinc causes the gold to precipitate from the solution in the form of a black powder, and zinc goes into solution in place of it. The black powder mixed with remnants of zinc shavings is removed from time to time, treated with acid to dissolve most of the remaining zinc and melted in crucibles with some fluxes. The molten gold is poured into moulds forming bars or bricks of cyanide bar-gold which is also sent to England to be refined.

Slimes treatment.—The special plants for treatment of slimes have been installed within the last couple of years. The slimes are so fine that the solutions could not be filtered through them in percolation vats such as are used for the sands. They are therefore mixed with cyanide solution and agitated, to secure complete solution of the gold, and the mixture of slime and solution (called pulp) is forced or allowed to flow into large rectangular iron tanks in which a great number of filter-leaves are suspended. Each leaf consists of a large flat frame covered back and front with a sheet of filter cloth. A pipe leading from the interior of the leaf, between the two cloths, is connected to a reservoir in which a fairly high vacuum is maintained. When the tank is full a tap is opened connecting each leaf with the vacuum and the solution is sucked through the filter-cloth while the suspended slime gradually forms a cake, one or two inches thick, on the outsides of the filter-cloths. The operation is then stopped, the tank emptied and filled with water to wash the cakes, again emptied and the cakes detached and sent to the waste dumps. The filter is then ready for another charge.

The solutions drawn off through the filter leaves go to zinc boxes and the gold is recovered just as in the sands treatment.

Old Tailings Dumps.

The old tailings dumps which have been through the amalgamation and cyanide processes of former years amount to nearly 10,000,000 tons. The amount of gold which they contain varies very much, some portions running as high as 3 dwts.

per ton while a great deal is under 1 dwt. The new cyanide treatment with its finer grinding and treatment of slimes will permit of the retreatment of considerable portions of the old dumps—probably some three to four million tons—yielding an average of from 1 to 2 dwts. per ton and giving a further return of £1,000,000 and possibly more.

The waste residues under the new treatment will probably be reduced to five or six grains per ton which means an increase in the recovery of gold and of the final output of the Field.

Grade and value of the ore.

The following statement shows the assay value of the ore sent to the mills, and its value in rupees, at intervals since 1898. It will be seen that there has been a steady decrease in the value of the ore mined and by some this would be regarded as indicating an impoverishment of the mines with increasing depth. It would be hard to say definitely whether or not such impoverishment is a fact owing to the very uneven distribution of the ore shoots, but it may be regarded as fairly certain that the mines will become less rich as greater depths are attained. The regular decrease shown in the statement is however very largely due to the fact that working costs have been reduced and that improved methods of extraction have increased the proportion of the gold which can be recovered with the result that large bodies of low grade ore, which would have been left untouched in former years as too poor to treat, can now be mined and treated at a profit. The inclusion of these lower grades of ore along with the richer ore from the shoots lowers the average grade and is a healthy sign of progress and development.

TABLE 3—*Grade of Ore in the Kolar Mines per Ton of 2,000 lbs.*

Name of Mine	1898		1900		1905		1910		1914	
	Grade of ore dwts.	Value Rupees.	Grade of ore dwts.	Value Rupees.	Grade of ore dwts.	Value Rupees.	Grade of ore dwts.	Value Rupees.	Grade of ore dwts.	Value Rupees.
Mysore ...	33·75	101·35	25·53	76·59	19·49	58·47	17·55	52·65	15·67	47·01
Champion Reef ...	30·55	91·65	33·20	99·60	18·10	54·30	11·002	33·016	12·48	37·54
Ooregum ...	16·35	49·05	16·09	48·27	10·35	31·05	12·97	38·91	12·19	36·57
Nundydroog ...	19·49	58·47	22·05	66·15	16·52	49·56	18·14	54·42	18·59	55·77
Balaghat ...	14·23	42·69	19·92	59·76	16·54	49·62	8·26	24·78	8·47	25·41
Tank Block ...	7·03	21·09	5·21	15·63	9·25	27·75	...	...	...	...
Coromandel ...	9·65	28·95	12·81	38·43	7·11	21·33	...	...	...	...
Nine Reefs ...	5·49	16·47	7·70	23·10	...	...	...	...	...	...
Road Block ..	...	...	5·77	17·31	...	...	...	...	..	...
Gold Fields of Mysore ...	...	...	13·76	41·28	...	...	...	..	...	...
Averages ...	23·99	71·97	22·10	66·30	16·53	49·59	14·47	43·41	14·11	42·33

Working costs.

The following statement gives the average working costs on the Kolar Field in the various branches of work. The reduction in costs is marked. Under the head of *mining* are included:—

	Rs.	a.	p.	
Development costing about ...	3	0	0	per ton milled.
Stoping (including timbering)	6	0	0	do
Hoisting do	2	10	0	do

The cyanide treatment now includes (1914)

Treatment of *sands* costing Rs. 1-2-0 per ton treated.

Do *slimes* do Rs. 1-4-0 do

In the last column of the statement the total costs in India, including administration, are given and now amount to about Rs. 19 per ton of ore milled. These however are not the total charges which have to be borne.

We must include about Rs. 2-4-0 for royalty, and Rs. 1-8-0 to 3 for London Office, depreciation, etc., making the total about Rs. 23 or 24 per ton milled. In order to pay these charges the ore must contain an average of 8 dwts. of gold per short ton. This gives us a rough figure whereby to judge whether an ore can be worked profitably or not under conditions similar to those at Kolar. As conditions vary this figure will rise or fall, and the case of the Wanderer Mine (see p. 13) may be referred to as one in which an ore containing some 10 or 11 rupees worth of gold ($3\frac{1}{2}$ dwts.) can be worked at a slight profit.

TABLE 4—*Costs on the Kolar Gold Field in Rupees per Ton of 2,000 lbs.*

Years	Mining		Milling	Cyaniding	Total including administration
	Per ton excavated	Per ton milled	Per ton milled	Per ton treated	
1898	13·39	18·00	3·81	2·01	25·77
1900	12·99	17·79	3·80	1·74	25·98
1905	9·78	13·38	2·39	1·16	18·51
1910	9·02	13·65	1·86	1·17	19·98
1914	8·76	12·66	1·75	1·20	19·56

With the foregoing brief account of the work being carried on by the leading mines of the Kolar Field we shall now pass on to the work done and prospects in other areas of the State, taking up the various schist patches or groups of workings seriatim. The information about some of the earlier work is often scanty, but since 1898 the principal workings have been inspected and reported upon by the Director and other officers of the department. Further details than can be given here will be found in the Reports of the Chief Inspector of Mines and for convenience of reference the dates of these reports will be given where necessary in the text in square brackets.

Before leaving the Kolar Field a few remarks may be made about prospects at the north and south ends of the Field.

New Kempinkote.—This property lies immediately south of the Mysore Mine from which point the auriferous schists extend south for a couple of miles before they are cut off by the Champion gneiss. In the early days of the Field much work was done here to a depth of several hundred feet and small patches of good ore obtained. The country is much disturbed and no large shoots were found. During the past two years work has been started to test the ground at greater depths by driving southwards from the 2,160 and 2,385 foot levels of the McTaggart's Section of the Mysore Mine. Some quartz up to 9 dwts. in value has been found, but nothing big or continuous and it is to be hoped that the work will be pushed on as far as possible as any success here would lead to the opening up of a considerable area of schist which is certainly auriferous.

The Balaghat Mine.—This occupies the whole of the northern end of the Field and includes the former Balaghat property as well as those of Road Block, Nine Reefs and Coromandel in which a number of shoots have been worked in past years on two or three lodes which may be regarded as discontinuous extensions of the Champion Lode Series. Recent developments in the bottom of the Balaghat Mine have been encouraging and may lead to extension of work southwards below the old Coromandel Mine. The developments northwards from the Nandidroog Mine in the lower levels of the former Tank Block and Oriental properties point in the same direction, and thus there are fair prospects of a considerable area of ground being opened up between the Oriental workings of Nandidroog and the new finds in the bottom of Balaghat.

About half a mile west of these lodes are the Oriental and West Balaghat lodes on which much work was done by the Road Block, Nine Reefs and Gold Fields Companies but which have now been abandoned.

Ahmed's Block.—This lies on the east of the Nandidroog Mine where there were some doubtful old workings. Half a dozen shafts were sunk, the deepest being 118 feet. Of these 4 were in the Champion gneiss and 2 in hornblende schist. Shafts Nos. 1 and 2 are in the gneiss. In No. 1 at a depth of 90 feet levels were driven for 80 feet on a vein which is said to have carried gold, but samples taken by Mr. Bocquet did not give more than 6 grains. In No. 2 there is a small quartz vein which is only 1 to 2 inches wide at the bottom and gave an assay of nearly 4 dwts. The work was inspected and reported on [1907-08] and the prospects were not sufficiently favourable to justify further expenditure.

KOLAR SCHISTS NORTH OF THE KOLAR FIELD.

Krishnarajpur.—Immediately north of Balaghat (Road Block) some loose quartz on surface showed gold and it was thought that this might come from an extension of the Balaghat lode. In addition to some shallow shafts and drives a shaft was put down over 300 feet and a cross cut started east. Nothing was met with and work was abandoned in 1899. Considering that some 4 or 5 lakhs were spent in machinery and sinking it is a pity that the cross cut was not extended further for the sake of exploration at the depth reached.

Plantation Block.—Lies to the west of Krishnarajpur and contains some dumps and filled-in old workings. Prospecting work has been taken up from time to time without success. At the present time work is going on at three small shafts on filled-in old workings and although nothing of importance has been met with it is probable that at least one of these points will be further explored.

East Betarayaswami.—A large block on the north of the two former. Prospecting work was started over ten years ago by Mr. Mervyn Smith who opened a large number of pits and trenches on a lode formation running through the eastern side of the block which was regarded by him as a possible extension of the Champion series. In many places vein quartz or lode formation on two parallel lines was opened up but the panning and assay results were poor.

Some distance to the west some old workings were opened up and a couple of shafts sunk to test the old workings. A level at a depth of 150 feet passed through some of the old workings and is reported to have given good values for about 150 feet south. Further work has been done recently by the East Betarayaswami, Limited, Syndicate, and the main shaft sunk to a vertical depth of 454 feet. Long drives at the 300 and 440 foot levels have opened up a well defined vein of quartz, which, for the most part, assays very low. At the 300 foot level quartz assaying from 5 to 30 dwts. was passed through for a length of 20 feet and it is evident that the shoot on which the old workings were made has dwindled and vanished in depth. Further work is in progress from the 440 foot level in the hopes of striking a new shoot in the quartz.

Shaw's Block (Badamakanhalli).—North of the last block and just north of the Kolar-Betamangalam road where the schist belt is narrow. Extensive prospecting work was carried out by Messrs. Shaw Wallace & Co. in 1907-08 and the work inspected and reported upon [1907-08]. Many thousand feet of trenches were made and 8 shafts sunk up to 71 feet in depth. Three lodes of ferruginous quartz schist were disclosed and numerous veins of bluish quartz most of which showed traces of gold but none of them carried payable values. The ferruginous quartzite carried a little gold in places as also did the quartz veins which penetrated them. The eastern or 'schist' lode gave the best results. It is 3 to 4 feet wide at surface and gave assays from a trace to 8 dwts. At a depth of 60 feet it had narrowed to 18 inches and gave from a trace to 4 dwts. Work was stopped in 1908 as there was no indication of any body of payable ore.

Jayamangalam.—This lies north of Shaw's Block and some deep prospecting is reported to have been done about twenty years ago. An incline shaft was sunk to a depth of 80 feet on an outcrop which is stated to have given 4 dwts. This result has not been confirmed since and the results obtained on sinking were practically valueless.

A few small old workings have been found north of Jayamangalam in the neighbourhood of Holali and Vitpalli, but washing of the dumps and float quartz gave practically no gold.

Manighatta.—North of Vitpalli the schists widen again to a large body and washings in the streams near Manighatta and Shagatur, frequently gave shows of gold. The area was examined by Mr. Lavelle and a number of trenches put in which disclosed many veins of quartz some of which panned gold. There is a large old working to the east of Manighatta village with a smaller working to the east of it. No other old workings are known and the isolated character of the large pit rendered people shy of spending money on it. In 1910 Captain Lethbridge started work on behalf of the North Kolar Syndicate and several shafts were sunk to a depth of 60 feet both close to the old working and on some of the veins disclosed in trenches to the north of it. The work was reported on [1911-12] and further work recommended which was carried out, under option by the Ooregum Gold Mining Company in 1911-12. The earlier part of the work showed that the old working was 30 feet wide at the north end at a depth of 60 feet but there was no shoot or vein continuing northwards. At the south end a small shoot of rich quartz was found but this vanished into valueless stringers a few yards to the south. The later work done by the Ooregum Company consisted in sinking a vertical shaft, 210 feet deep, to the west of the old pit, from the bottom of which a cross cut was driven east under the old working but failed to find any quartz of value. Another cross cut was put in at the 118 foot level and intersected a small vein below the south end of the pit. This was driven on north and south for about 145 feet for the greater part of which the vein averaged about 15 inches of quartz with about 6 dwts. of gold and this increased to 18 inches and 15½ dwts. in a rise up to the old working. At the north end of the level the quartz went into stringers, but in a winze below 6 inches of quartz assaying 14½ dwts. of gold was found.

The general results show that the old working was of considerable width and about 150 feet long. It may have been sunk on a large lens of quartz or bunch of veins but the quartz does not continue north and south. Some of the quartz is left below the old working and this thins out and decreases in value at 118 feet. There is no trace of it at 200 feet.

After a careful examination it was suggested that the vein may have been faulted to the east between 118 and 200 feet from surface though this is very doubtful. The results obtained are not encouraging, but some further work might be recommended in continuation of the winze at the north end of the 118 foot level to see what becomes of the vein and whether it opens out again along a northerly pitch.

The large area of schist in which the Manighatta old working is situated is very similar in character to the Kolar Field and carries numerous quartz veins which are slightly auriferous. The marked absence of old workings is an unfavourable feature and means the absence of specific points for the start of prospecting work. Trenching has not led to any discoveries and it is only on account of the similarity of the country to that of the Kolar Field that one might be tempted to suggest a purely speculative effort, to the extent of 5 lakhs or so, to be spent and a widely spread series of trenches and small shafts and cross cuts. It is possible that the extensive capping of laterite and laterite soil may conceal valuable outcrops which under other circumstances would have been marked by old workings.

THE CENTRAL OR CHITALDRUG SCHISTS.

The various points at which work has been done in the Chitaldrug Schists will be taken in order from north to south.

Halekal.—East of Davangere. Mr. Bruce Foote observed numerous dumps between the village and Halekalgudda and considered that the surface soil had been largely turned over. During survey work in 1903, Mr. Slater found some old workings on Halekalgudda and some prospecting work was done between 1907 and 1909, under prospecting license No. 100 without success. Traces of gold were found down to a depth of 70 feet, but no auriferous veins were discovered. The old workings appear to be in or adjacent to quartzite and have been examined more recently (1915) by Mr. Coleridge Beadon, who did not consider them worth further attention.

Honnemaradi.—South-east of Jagalur where Bruce Foote reported the existence of fine reefs and veins of quartz. In 1905, Mr. Sampat Iyengar discovered an old working which is reported to be in the grey-trap of Chitaldrug. A prospecting license was taken out by the Madras-Mysore Mining Syndicate in 1907, but no encouraging prospects were found.

Kotemaradi and Gonur.—North-east of Chitaldrug. A number of old workings were noted by Bruce Foote and a mining lease taken by General Cole in 1890. No records of any work done are available, but some of the pits were examined in 1897, by Mr. Sambasiva Iyer, who found gold in the surface materials and in 1906, several of the pits and burrows were examined and prospected by the department. Two were found to be irregular tunnels about 25 feet in length and two were open pits. None of these showed any defined vein or lode, but the schist contained many stringers of quartz which assayed nil. Washings of the earth from the sides and bottom showed a little gold as also did those from the nullas to the north of the workings. Subsequently a license was taken out by the Madras-Mysore Mining Syndicate and a small shaft sunk and an adit driven for 60 feet without obtaining any results of value. A considerable amount of work was also done in the hills east of Chikannanhalli a few miles to the north.

In the central body of the schist between Hiriyur and Huliyar a large number of old workings, not previously known, have been found during the course of survey work by Mr. Sambasiva Iyer and by Messrs. Wetherell and Sampat Iyengar and the presence of gold ascertained by washing the dumps and materials from the pits. Subsequently the majority were closely prospected by Mr. Randolph Morris and others and a number of licenses and leases taken out by him and by the Indian Mines Development Syndicate. The chief points worked are the following:—

Bodimaradi.—About seven miles north-west of Marikanave. An old working was found by Mr. Sambasiva Iyer on the flank of Iplara hill. It is a deep narrow excavation, bands of limonite with veins of powder quartz lying between in earthy ferruginous quartzite.

An adit has been driven through the western bed of quartzite and south through the limonite passing through and beyond the old working and at the south end a winze has been sunk about 100 feet and some short levels driven. It was expected that the run of stuff which the old workers followed would be met with in the winze, but nothing satisfactory was encountered. A stringer of rich quartz was passed through but led to nothing. An interesting feature is the fact that the limonite itself showed some 3 or 4 dwts. of gold very consistently over width of about 8 feet for a short depth, but this was not found to continue at the lowest level reached. [1903-04.] The work was abandoned in 1904.

To the south of Javangondanhalli, a number of blocks were taken up and much work done at several points of which we may mention the following :—

Javanhalli Block.—The workings are in hornblende schist with some dark chlorite schist. Several shafts were sunk up to 200 feet in depth and a number of drives and cross cuts put in to test the ground beneath the old workings but in no case was any payable vein or lode found and work was suspended in 1908. [1907-08.]

Annesidri.—The workings are to the west of Javanhalli and also lie in hornblende schist. No valuable results were obtained.

Ramanhalli and *Ajjanhalli.*—These lie five or six miles to the south of the above in the chloritic schists. Little work was done at Ramanhalli as the surface prospects were not encouraging.

At *Ajjanhalli* extensive adits and cross cuts were made in the Gavigudda hill in which a very considerable ore body was met with at depths of 100 to 300 feet. The main adit is over 600 feet in length in ferruginous quartzite which gave assays from $\frac{1}{4}$ to $6\frac{1}{2}$ dwts. In the main cross cut east for about 150 feet the mixed chlorite and ferruginous schists gave assays of from 4 to 8 dwts., but the values sank to 1 dwt. or less in the cross cuts to the north and south of this. The work disclosed a very considerable body of schistose lode matter which was very carefully sampled and a bulk sample of 200 tons sent to Kolar for treatment. The average assay value of the bulk sample was 3·69 dwts. but the mill extraction was only 1·46 dwts. per ton.

These results were not considered good enough to warrant further work but they are more encouraging than have been met elsewhere in this area and might be deserving of further attention. [1907-1908.]

Dindivara.—Some pits which were considered to be old workings were found on two runs of ferruginous quartzite south of Dindivara village about six miles west of the above series of workings. Mr. Bosworth Smith took out a license in 1907, and put in a number of pits and trenches from which small values were obtained and he considers that the gold is in these ferruginous quartizites as well as in the quartz veins in them. The gold was very small in quantity and appears to be less in depth than at surface.

Bellara.—Work was carried on for several years by the Indian Mines Development Syndicate in connection with some old workings originally found by Mr. Sambasiva Iyer and subsequently prospected by Mr. R. H. Morris. They are in a large mass of altered diabase which intrudes the chlorite schists. The principal workings are on a small hill where there is an outcrop of quartz (Bellara reef) which gave some good shows of gold on panning. Three shafts were sunk and levels driven at 130, 230 and 330 feet. There was a good vein of quartz but the values were very low and work was stopped in 1905. At the western foot of the hill what is known as Tank reef was located after a considerable amount of prospecting, and found to be dipping west. Altogether ten shafts were sunk over a length of about 2,000 feet. The deepest was a little over 400 feet and a number of levels from this and other shafts disclosed the existence of a quartz vein varying from a few inches to two and a half feet in width which assayed from a trace to about three ounces with occasional richer patches. A considerable proportion could be taken out at an average of 9 dwts. or so, but the total tonnage is too small to justify the erection of a plant. At the deepest point the quartz was nearly 4 feet wide but of no value and at other points the values at depth were all small. At one time the results appeared to be quite promising, but the poor results obtained in depth caused the mine to be abandoned.

In the southern portion of the Chitaldrug schist belt and in the outlying stringers near it, several old workings and dumps have been noted. A large number of leases were taken up in the early days, but no promising results were obtained and very little work done. The following may be mentioned :—

Honnebagi.—East of Chiknayakanhalli. There are a number of shallow workings near the edge of the schists which are partly hornblendic. Some trial pits on the quartz veins gave no gold.

Kalinganahalli.—Just south of the Kunigal road. There are a number of dumps from which gold can be washed and probably represent the turning over of the surface soil and debris.

Nagamangala.- On the outlier of hornblendic and talcose schists west of the town there are numerous quartz veins which were favourably noticed by Mr. Bruce Foote. Little work appears to have been done on the old leases which have since been abandoned. A number of these veins were sampled by Mr. Wetherell during survey work but gave nil to traces of gold with sometimes 1 or 2 dwts. of silver; and further work does not seem to be advisable.

Hunjankere.—On a small patch of hornblendic schists about 7 miles east of Seringapatam. There are a few old workings here which were tested in 1907 by Mr. J. G. Hooper under an existing lease [1906-07]. Several shafts and trial pits were sunk and three quartz veins tested one of which gave occasional assays up to 10 dwts. The country and lode matter is rather like that at Woolagiri, but on a small scale and no indications of any body of ore were found.

Butgahalli.—North of Bannur. There are some old workings here on a small patch of hornblendic schists. These were prospected by the department in 1905-06 and two shafts sunk and several trenches made. Some small shows of gold were obtained but nothing sufficiently encouraging to warrant further work. An extended series of alluvial washings were made at the same time at Hunjankere but gave only minute traces of gold.

WEST CENTRAL SCHISTS.

A number of old workings have been recorded along a stretch of country in the Hassan and Mysore Districts from

Banavar to south of Nanjangud. The positions of these are shown on the map. They lie in small shreds or patches of hornblendic or talcose schist or schist and gneiss and many of them appear to be unimportant and have failed to attract serious attention. On the more important or promising looking a good deal of work has been done of which the following is a brief record :--

Yelvari.—Near Haranhalli. These were tested by the Mysore-Haranhalli Gold Mining Company in 1889-1890. A trial crushing of a bulk sample of the stone appears to have been made from which 25 ozs. of gold were obtained, but the results were too poor to justify further work which was suspended in 1890 and the Company transferred its activity elsewhere.

Kempinkote.—(Hassan). They lie on an isolated patch of hornblendic and talc-chlorite schists to the south of the Nuggihalli schist belt where there is a very large old working (over 600 ft. in length) with a smaller working to the north of it. The property was taken up by the Kempinkote Gold Field, Ld., with a capital of £170,000 and a great deal of work was done from 1893 to 1896. The ground beneath the old workings was tested by two shafts to a depth of 500 feet, several thousand feet of drives and cross-cut being put in. No very definite vein of quartz or fissure lode was found, but a wide zone of auriferous schists with numerous veins, bunches and lenses of quartz was disclosed which is stated to have been 70 feet wide in places and sometimes up to 150 feet in width with intervening schist bands. Much of the quartz, especially in the large veins, was very poor, but the banded schist formation sometimes gave an average of 8 to 10 dwts. for considerable distances and widths. The occurrence of rich pockets assaying up to 10 ozs. was a noticeable feature and helped to raise the average of some of the drives, but they were too few and far between to produce any considerable or reliable influence. A great deal of the lode formation went under 1 or 2 dwts. in value and the formation appeared to be narrowing in depth. Taken as a whole the formation is of low grade and if taken out in bulk the average would probably not exceed some 2 dwts. per ton. We believe that this represents the opinion of Mr. R. H. P. Bullen who was in charge of the work and that there is some prospect that the grade might be improved somewhat by selection or sorting. There is some reason to hope that the property will be taken up again and given a further trial in view of the improvements in treatment and extraction which have taken place in recent years. If sufficient material could be obtained to give an output of 100 to 150 thousand tons a year of an average value of 5 dwts. or so and with a simple process of extraction the prospects of working at a profit would not be beyond hope.

Bellibetta.—There are a number of workings in outliers of the schists to the west of Krishnarajpet. Of these the most important are on the Bellibetta hill and several mining leases were taken out in 1886. Little work appears to have been done, but in 1901-02 an option was acquired by the New Kempinkote Company and some shafts sunk to test the reefs which the old workings are supposed to have followed. The quartz was practically valueless. Washings from the dumps and assays of float quartz gave small shows of gold which in no case exceeded 1 dwt. per ton.

In the Mysore District there are several old workings in the neighbourhood of Hunsur and Nanjangud. Of these the most important are those at Woolagiri (Volgere) and Amble and a large amount of money has been spent from time to time in testing them and the schists in which they lie and they have been closely examined and reported upon by the department.

Amble.—On this block the old workings were tested about 1895 by a small Syndicate and some good specimens obtained. In 1899 to 1901 work was taken up by the New Kempinkote Company and at North Amble shafts and levels to a depth of 178 feet disclosed a quartz vein about 5 feet in width which was auriferous, but the values were low and seldom ran above 4 or 5 dwts. At South Amble sinking was continued to a depth of 200 feet, but with the exception of a small vein below the old working which assayed a few dwts. nothing was found. A large vein of pegmatite was encountered which gave assays as high as 15 grains per ton. A great many trenches and pits were made all over the strip of schist and many of the quartz veins and alaskites were found to contain small amounts of gold but nothing of any value for mining. [1901.]

Woolagiri.—A large old working lies to the north of Amble workings in a separate patch of hornblendic schist. Early work is said to have yielded some rich samples from a shaft 96 feet deep from which a cross-cut was made beneath the old working. In 1906 work was taken up by the Nanjangud Gold Field and levels, etc., driven at 96 and 126 ft. disclosing a complex lode of quartz and altered schist over 20 ft. wide. The mine was sampled and reported upon departmentally the result of which was to show that the lode averaged about 4 dwts. of gold per ton about 1/5th of which is in pyrites. [1901 and 1906-7.] This is too low to pay and it was suggested that much of the lode material (white quartz, granite, etc.) could be picked out raising the remainder to from 7 to 10 dwts. and that if a sufficiently large body could be proved it might be possible to make it pay. A vertical shaft to a depth of 200 ft. was recommended and exploration at that level to see if the lode continued or improved. This work was carried out, but it was found that the lode had narrowed considerably in depth and that notwithstanding some bunches of good ore the average value was low.

A five-head stamp mill was put up and various trial crushings made from 1906 to 1909. The trials on the general samples of ore sent to the mill averaged 3·26 dwts. of bar gold per ton and on picked ore 5·07 dwts. The tailings probably averaged about 1·5 dwts. per ton.

The mine was finally reported upon by Mr. Bosworth Smith (1) in 1913 on behalf of the Eastern Development

(1) Mysore Geological Department, Records, Vol. XIII p. 157.

Corporation and as his report was unfavourable work has been abandoned.

HONNALI GOLD FIELD.

This first attracted attention in 1880. A large number of leases were taken out in the neighbourhood of Kudrikonda and Palavanhalli and were acquired by the Honnali Gold Mining Company with a capital of 4 lakhs of which about 2 lakhs was available for working. Owing to the prevalence of gold in the soil, some rich float quartz and some very high values were obtained during prospecting work. Very sanguine reports were drawn up and a good deal of money was spent on a 10-head battery, percussion tables, reverberatory furnace, arastras, etc., before the value of the ore bodies were proved. The final result was a shortage of money which might have been more usefully spent in further exploration. The principal work was done at Kudrikonda where there were some old workings most of which were proved to be erratic and not very deep. At the main shaft a reef called Turnbull's reef was opened up to a depth of 165 feet and found to be a lenticular shoot pitching north with quartz up to 5 feet in width which pinched into stringers towards the bottom. Four other shafts were sunk on the lode to the north of the main workings but gave poor results. The main shoot appears to have contained very rich patches, up to 35 ozs. to the ton, but the average result was quite low. Altogether 2,586 tons of quartz were obtained and yielded 528 ozs. of gold, or an average of about 4 dwts. per ton. This average is too low to pay and the quantity of ore to be obtained is apparently small. A report of the Honnali Company published in 1885 sums up the results of working by saying that each ounce of gold had cost the Company Rs. 139-10-5, while its sale value was only Rs. 45-9-9.

Funds being exhausted the mine was closed, but shortly afterwards The Honnali Tribute Syndicate started further work most of which was carried out by Mr. James Young who has kindly furnished the following particulars:—

The North Air Shaft, which lies 160 feet north of main shaft and had previously reached a depth of 90 feet, was continued to 260 feet and several short drives and cross-cuts put in. At 150 feet the reef improved to 4 feet in width and showed gold estimated at from 18 dwts. to 34 ozs. per ton. At 164 feet it passed out of the shaft. At the 200 feet cross-cut only stringers were found, but in a drive north some small quartz is reported to have been several ounces in value. About 130 tons of quartz obtained during these operations were put through the mill and yielded 100 ozs. of gold. Notwithstanding some high values the work done failed to reveal any valuable body of ore and the mine was finally closed down although Mr. Young was still very sanguine about finding something more substantial with further work.

There can be no doubt about the existence of small rich lenses and patches in this field and that others would be met with if the workings were considerably extended. Unfortunately a few rich patches do not make a mine and the cost of finding them and extracting the gold is likely to exceed the value of the gold won as shown by the milling results of the Honnali Company.

On the other hand these isolated patches may easily account for the prevalence of gold distributed through the soil of the area as many of them must have been exposed and broken down, with resultant separation of the gold, during the long denudation of hundreds and probably thousands of feet of the schists in which they occur.

The number 15 Honnali Gold Mining Company.—Opened a mine about 1 mile north-west of the Honnali Mine, to a maximum depth of 315 feet. The veins and stringers were poor. The best result appears to have been a vein 18 inches wide worth 4 to 5 dwts. which was found in the north level from Air Shaft.

Palavanhalli Gold Mining Company.—The Company did some work at a point four miles south-east of the Honnali Mine, where there is a shallow old working. A main shaft was sunk to 100 feet on a cross-cut east driven but no ore of value was encountered.

After a long period of inactivity some further attention has been paid to this field during recent years. Numerous washings and trial pannings have been made by the department without locating any promising material.

Under prospecting licenses held by the Eastern Development Corporation a considerable amount of prospecting has been carried out under Mr. Bosworth Smith which has been referred to already (p. 11) and which will be continued.

On several other blocks in the neighbourhood of Palavanhalli a good deal of work was done a couple of years ago on behalf of some of the Kolar Companies, but the results were poor or nil and the licenses have been given up.

SHIMOGA-TARIKERE GROUP.

A reference to the map will show that a very large number of old workings have been found in the schists around the Shimoga and Tarikere masses of granite and gneiss. In these schists some runs of fine granite, quartz porphyry, quartzite and crush breccia or conglomerate have been found and are regarded as probable representatives of the Champion gneiss.

At Honnehatti, Nandi, Ajjampur and Bukkambudi the old workings have been known for a long time past, but a very much larger number were discovered subsequently—chiefly by Mr. H. K. Slater—during the course of survey work.

The following is a brief account of the mining and prospecting work at the principal points starting from the west side of the group.

Chornadihalli.—These workings lie about eight miles south of Shimoga. Mr. Slater found a large number of pits over a considerable area both in the chloritic schists and in the potstones. The area was prospected and reported upon [1906-07] by Mr. Balaji Rao who obtained indications of gold from some of the pits and adjacent nullas. No auriferous quartz was found and it is possible that many of the pits were not for gold. The prospects are not promising and no serious work was attempted although a prospecting license was taken out and held for several years.

Honnehatti.—South of Benkipur and close to the Bhadra river a very large number of old workings occur on the Honnegudda hill and on the flats to the south of it. These have attracted a great deal of attention since 1887 when a lease was taken out by the Mysore-Nagar Gold Mining Company. In more recent years the ground has been extensively prospected under Mr. Bosworth Smith and Capt. Lethbridge and the results may be summarized as follows:—

In the saddle on the Temple Hill are large old workings which were tested by an adit driven into the hill for 294 feet and from which a rise was put up into the old workings. A lode formation was found consisting largely of massive quartz with pyrites and on this some levels were driven and a winze sunk to 74 feet below the adit level. The samples showed that the lode or vein averaged about 2½ dwts. per ton, the highest assay being 8 dwts. The pyrites carries gold to the extent of about 12 dwts. per ton. This material was obviously unworkable and attention was directed to the low ground between the hill and the river.

In this ground there are a very large number of old workings spread over a large area, the principal ones being grouped along three parallel lines. One or two of these are more than 50 feet deep, but the majority are much shallower. The Mysore-Nagar Company sunk two shafts and put in some pits and trenches but the results were poor.

The No. 1 shaft was 100 feet deep and in a cross-cut west at 80 feet a vein eight inches wide assaying 2½ dwts. was found. Nothing of value was found and as water was heavy work was stopped.

The White Cedar shaft was sunk for 95 feet and at 83 feet a drive was put in just below the old working. Stringers and veins of quartz were found which occasionally showed gold, but the average results were very low.

Mr. Bosworth Smith reported on the property in 1903 and found that the mineralized lode from the bottom of White Cedar shaft gave about 3½ dwts. and from the drive at 83 feet some 7½ dwts. He also found that picked samples rich in sulphurets (iron and copper pyrites and blende) gave 14 to 17 dwts. and that the concentrates from these gave about 2 ozs. per ton. He formed the opinion that although there may have been a good deal of free gold in the broken-down and weathered materials near the surface, on which a large number of the shallow old workings were made, at greater depths the greater part of the gold was in the pyrites and that the ore would be refractory and require concentration. He thought that considerable bands of mineralized lode matter (quartz and schist) might be found which would pay to extract.

Subsequent work has not disclosed any considerable lenses or bands of payable material although several thousand feet of trenches were put in and a large number of pits sunk on veins which showed from a trace to 20 dwts. to the ton, but which invariably pinched out or became poor in depth. The results have been very disappointing but it may be noted that Mr. Bosworth Smith's main recommendation was not carried out. This was to sink a shaft to 300 feet a little west of the White Cedar shaft and ascertain whether any sufficiently large lenses or bands of heavily mineralized lode matter were to be found below water level. The expense of the necessary plant and the poor results already obtained no doubt accounted for this, but it is possible that some one will still have the courage to carry it out.

Tambadihalli.—Around Tambadihalli and Shinganmane many old workings have been found in the jungles—mostly nearly filled in and covered with soil and leaves. Work was carried on for several years by the Shimoga Gold Fields, details of which will be found in the Mines Reports for 1906-07 and

1907-08. At seven different places shafts were opened up to a depth of 100 feet or so and drives put in. In three or four places rich stringers and lenses of quartz were found running several ounces to the ton; but in no case did any of them continue for any considérable distance or make into a workable body of ore.

Teak Plantation Block.—Some work was done in 1908-09 on the old working here which was unbottomed. It was found that the pit had been sunk on a small rich shoot of quartz which had a length of about 40 feet and carried several ounces of gold and no pyrites. At 20 to 30 feet below water level the shoot had shortened to 20 feet and was evidently pinching rapidly and as the water was very heavy, work was stopped. It is a point which will doubtless be attacked again if the neighbouring workings at Jalagargundi are reopened and staff and machinery are available.

Jalagargundi.—This is the most important point in this group. There is one very large pit and a number of smaller ones scattered about in chloritic and talcose schists and potstones. A large amount of work has been done [1907-08; 1908-09]. No 1 shaft was sunk to a depth of 230 feet close to the large pit and some quartz about two feet wide, said to be worth 15 dwts., was found at about 160 feet. At 190 feet the quartz was wider, but carried only from a trace to 4 dwts. At No. 2 shaft, a lode was cut at 170 feet said to be worth 15 dwts. and 10 or 12 feet wide. At 200 feet it is about 11 feet wide and said to be of fair though variable value. In a drive to the west the lode became poor, but for 105 feet to the east it was estimated to be worth over 1 oz. In 1913 the lode along the east drive was stoped out for 150 feet for a height of 5 feet of which a general sample gave just over 10 dwts. By picking out the white barren quartz the balance (69 per cent) gave an average of nearly 14 dwts. [1913-14].

The lode is a sort of finely granular and banded quartz schist with some calcite and chlorite and fine parallel lines of oxide of iron dust. Alongside and penetrating it is a large blow or vein of white glassy quartz which is barren. The gold is mostly free and the lode is richly studded with small crystals of pyrites which carry little if any gold. Work is stopped at present, but it is expected that fresh funds will be forthcoming to continue operations.

Shiddarhalli.—The old workings are on the crest of some low hills and at the bottom of the principal working the lode which was mixed quartz and schist gave some 4 dwts. per ton. An adit was driven from the north face of the hill and cut the lode formation at 291 feet about 100 feet below surface. The lode was driven on for 120 feet east of which the first 50 feet was on an average 5 feet wide and about 9½ dwts. in value and from there to the end about 6¾ dwts. and getting narrower and finally splitting up. The west drive disclosed a body of ore 5 feet wide giving assays of from 6 dwts. to 1 oz. with an average of 12½ dwts. At 45 feet a cross lode carrying graphite was met with, beyond which the main lode narrowed from one foot to stringers in a distance of 15 feet. Several other drives were put in showing low values and levels were driven at 75 feet below the adit level which showed very crumpled and disturbed country and practically no lode formation of any value. Work was suspended in 1913 as results did not justify further expenditure, the small run of ore below the old workings having disappeared in depth as well as east and west and the country being too disturbed to hold out much hope of picking up any continuation of it.

Nandi (*Hoshalli*).—A few workings occur between Shiddarhalli and Nandi Hill, south of Tarikere, but nothing has been found by the prospecting work done at several points. The old workings at Nandi and Chattanhalli were prospected departmentally by Mr. Primrose in 1897 (Records Volume II, pages 57-61) who found little except small shows of gold in some of the nullas. Since then the ground has been held under a mining lease and two of the workings on Nandi Hill cleared out to depths of 120 and 210 feet. The assays did not exceed a few dwts. and the prospects have not been considered sufficiently good to warrant much expenditure and comparatively little work has been done. Recently [1912-13] one of the workings on the west side of the Tarikere road was tested by a vertical shaft to a depth of 198 feet and some quartz veins of little value found.

To the west of the long series of workings described above some others have been found at *Hoshalli* and *Devrukal* (Aramballi) not far from Yedahalli. Those at Hoshalli are in dark hornblendic rocks and amphibolite and the pits and trenches disclosed little of interest with the exception of a vertical vein about 4 inches wide giving assays up to 10 dwts. but showing no tendency to widen out.

At *Devrukal* the workings are in potstone and talcose schists. The dumps gave hardly any traces of gold and a long adit driven below the largest pit failed to find any lode of value. It is by no means certain that these workings were for gold, but no other mineral has been observed with the exception of a little chromite.

Ajjampur.—Passing to the north side of the Tarikere gneiss we come to some old workings on the hills to the west of Ajjampur. These were described by Mr. Sambasiva Iyer in 1897 (Records, Volume I, page 92) and the subsequent work inspected and reported upon by Dr. Smeeth [1901]. The workings are in a series of chloritic and felspathic quartzites or quartzose schists which are now thought to be associated with the Champion gneiss. There are two large pits named *Hondonna* and *Hakkidonna* and a good deal of work was done by the Kadur-Mysore Gold Mining Company. *Hondonna* lies a little north of the temple on the top of the hill. It is a large pit choked with debris and an adit was driven which entered it at 150 feet below surface. Little information was available as to what had been found but apparently nothing good. At *Hakkidonna*, which is on the slopes of the hill at a lower level, the old working is in the form of an irregular, steeply-inclined shaft or burrow which has been proved to a depth of 300 feet. Adits were driven in and levels and drives opened up round the old working, to a depth of 300 feet, which failed to reveal any valuable body of ore. The shape of the working points to a pipe or narrow shoot of ore having been taken out. A large number of samples gave very poor results, the highest being 2·2 dwts., and there appears to be nothing to encourage further expenditure.

Bukkambudi.—A few miles north of Ajjampur on the hill overlooking the tank. There are considerable excavations with inclined and branching tunnels or burrows in a series of talc-chlorite schists veined with quartz and calcite. The workings originally attracted the attention of Mr. Mervyn Smith who applied for a mining lease but did not take it up or do any prospecting. He reported the presence of zinc and lead sulphides with some silver. The workings have been examined departmentally during the course of survey work and there seems to be little to justify expenditure on them. The irregular shape and branches appear to indicate that some branching shoots or impregnations were followed and taken out. The lead and zinc sulphides are in irregular bands or streaks in the rock and samples broken from the faces give less than one per cent of concentrates containing galena, blende and pyrites in a fine state of division. Small veins of quartz as well as the mineralized rock give small traces of gold and it is probable that the old workers removed some small shoots or richly impregnated and oxidised patches of ore carrying free gold. So far as can be seen the quantity of mineralized rock is small and the percentage of mixed concentrates insignificant.

SUMMARY.

An endeavour has been made to summarize as briefly as possible the present state of our knowledge about the occurrence of gold in Mysore and the prospects of further developments of mining work. It will be evident that the hopeful predictions of Bruce Foote and of many of the earlier prospectors have been seriously discounted by the large amount of mining work which has been done at very considerable cost. These predictions were based on the successful results which were then being obtained beneath the old workings at Kolar, on the fact that many other old workings were known in other parts of the State but not tested, and on the fallacy—then so prevalent and not yet quite dead—that even though a mine or lode was comparatively poor at surface the odds were in favour of its increasing in richness at greater depths.

The work which has since been done by the Geological Survey and by various mining and prospecting parties has shown that the Kolar Gold Field possesses unique features in the number and size of the rich shoots situated on one or more well defined veins (which might properly be described as fissure veins) which are not repeated in other parts of the State where old workings occur. This would not prevent the opening up of individual mines if the shoots on which the old workings were sunk were found to continue in depth, and some may yet be found to do so. In the vast majority of cases however we have definitely shown that this is not the case and that many of the old workings are on what may be regarded as the mere stumps of shoots remaining after denudation of the upper parts. Many others, especially in the chloritic series, have been excavated on small rich lenses of limited extent and not connected with other lenses by well-defined veins which could be followed in the hopes of finding other lenses within reasonable distances. Other workings again are on veined or impregnated zones of schist the upper weathered portions of which—in which there may have been secondary concentration—were sufficiently rich in free gold while the unaltered portions below are too poor to pay.

The Kolar Gold Field is likely to continue a successful career for several decades and the area of ground mined may possibly be extended on the south and near the north of the Field. It is hoped that some further work will be done at Manighatta in view of the fact that a small shoot has been found, that this large body of schists is so similar in character and disposition to the Kolar Field and that gold is prevalent in the soil and nullas of the area.

In other parts of the Province work will no doubt be resumed later at Jalagargundi and on the Honnali Field; and the prospects of opening up some large low grade bodies of schist or lode, susceptible of cheap mining and extraction, at such points as Honnehatti, Ajjanhalli and Kempinkote (Hassan) may yet attract the attention of capitalists who are prepared to spend considerable sums on speculative ventures.

Iron.

Iron Ores.

Iron ores are widely distributed in the State but very variable in character; and in comparatively few places are they found in sufficient abundance and purity to be worth attention for work on a commercial scale under modern conditions.

The following classification seems to be in accordance with the numerous observations so far recorded by the survey:—

(1) Banded ferruginous quartz rock which occurs as a common integral component of the Dharwar Schists.

(2) Desilicified portions of (1) with, in some cases, addition of iron from solution or by metasomatic replacement of quartz and silicates. These form rich hæmatite and limonite ores.

(3) Zones or layers of massive ore probably the result of the metasomatic replacement of silicates (igneous and metamorphic schists) by oxides of iron. These are either limonites or hæmatites and are sometimes associated with (1) and sometimes not. In some places they are associated with manganese ores.

(4) Magnetite and hæmatite lenses which appear to be of magmatic origin associated with ultra-basic rocks intrusive into the Dharwar Schists. They are usually highly titaniferous.

(5) Quartz magnetite ores which appear to be of magmatic origin and genetically related to the Charnockite series and therefore subsequent to the Dharwar Schists and to the fundamental gneiss. There are some runs of solid magnetite-hæmatite ore in the same neighbourhood which may belong to this series, but as connecting evidence is wanting we have not definitely classed them.

A note on these various types and their mode of occurrence will be found in Records Volume XIV, page 34, and the present notes will be confined to the more important localities which have been investigated and the quantities and character of the ores available. A number of analyses are given in Tables 5, 6 and 7 and will be referred to where necessary by their serial numbers.

ORES OF THE BABABUDAN HILLS.

The Bababudan Hills lie a few miles north of Chikmagalur in the Kadur District. They form a ring or horse-shoe-shaped chain of hills enclosing the Jagar valley with an opening at the west side where the Somavahini river flows out. The crest of the ring is formed nearly entirely of banded quartz iron ores (ferruginous-quartzites) dipping inwards at angles of about 45°. The iron ore in these rocks is largely hæmatite with some magnetite. In places, chiefly along the eastern crest for some miles north of Attigundi, the rock contains much more magnetite than hæmatite and bands of the former, up to 2 or 3 inches thick, alternate with finely granular quartz.

Magnetite Ores.

These more magnetic portions of the series yield from 35 to 50 per cent of magnetic concentrate, but the results which could be obtained in commercial concentrators and the grade of the concentrates have not been determined yet. Large quantities of such concentrates could be obtained but they would be two or three times as expensive as the hæmatite ores which will be described below and the expense would be justified only if the product was very high in iron and very low in impurities—especially in phosphorus and sulphur. This is a point to be determined by further investigation.

Hæmatite and Limonite.

On the eastern side of the chain the ores lie at surface in gentle undulations with some steeper folds and crumples. The lower layers are thick beds of the banded ferruginous

TABLE 5—*Analyses of surface samples of the Bababudan Iron Ores (dried at 100° C).*

Serial No.	Registered numbers	H_2O	SiO_2	Al_2O_3	Fe	Mn	S	P	TiO_2	Remarks
1	$S_2/477$	4·06	0·76	3·03	64·22	trace	0·034	0·048	...	From main scarp, Kemmangundi (Nos. 1–4)
2	$S_3/29$	...	1·75	4·67	61·03	...	0·029	0·043	...	
3	$S_3/30$	...	1·56	0·53	61·75	...	0·053	0·036	..	
4	$S_3/31$	...	1·70	5·34	59·18	...	trace	0·082	...	
5	$S_2/479$	8·34	3·63	6·56	55·11	0·80	0·502	0·044	...	Banded ore and ochre in road cutting.
6	$S_3/26$	...	3·23	10·04	48·08	...	0·037	0·242	1·05	Lateritoid ore on top of No. 5.
7	$S_3/27$	...	0·83	6·90	62·05	...	0·015	0·037	...	Central portions of Kemmangundi ore field. (Nos. 7–10)
8	$S_3/28$	...	1·01	0·10	65·33	...	0·023	0·069	...	
9	$S_3/96$	...	...	...	...	...	...	0·019	...	
10	$S_3/97$	...	...	...	...	...	...	0·041	...	
11	$S_3/86$	...	1·43	...	65·08	trace	trace	0·046	nil	Outcrops near Kemmangundi gorge. (Nos. 11–13)
12	$S_3/87$	...	2·40	...	62·27	0·134	0·038	0·049	trace	
13	$S_3/88$	...	0·88	...	64·55	0·089	0·039	0·045	trace	

(The dot in the table indicate that the element has not been determined).

quartzite which are overlaid by a series of banded iron ores and ochres with numerous layers, bands or lenses of hæmatite and limonite. Many of these harder bands, which may be several feet thick, outcrop in scarps or in long lines of disjointed blocks over an area of 30 square miles or so from Kemmangundi on the north to Attigundi on the south and between Kalhattigiri and Virupakshikan, east and west. The various ore fields or patches of ore are separated by intrusive diabases or diorites, which are often altered into ferruginous clays, or by patches of soil and jungle or ferruginous quartzites where the overlying series has been denuded away. A great many million tons of ore exist in this area but in widely separated patches, and transport from one point to another would be difficult owing to the roughness of the country and the numerous ravines and nullas. For practical purposes it would be necessary to select some particular ore field where sufficient ore could be obtained to run the proposed smelting plant for many years.

Residual Ores.

It is interesting to note that in some places the ferruginous-quartzites appear to pass upwards into laminated and porous hæmatite by the removal of the quartz in solution. This is well seen along the track about ¼ mile north-west of the bungalow on △5590 and at points round the north-west slopes of the Giri. A pit at the former point was sunk in this ore at a little higher level than the point at which the underlying banded quartzites are exposed in a nulla close by. An average sample of the pit is shown in analysis No. 14 and shows good ore with practically no silica. There is a large quantity of this material but it is friable and would probably produce too much fines for blast furnace work. The only point which raises some doubt as to its origin is the amount of alumina present (nearly 10 per cent). It is not known how much alumina the banded quartzites contain and the large amount of this constituent rather suggests that there may have been intercalated bands of trap in the original rock.

TABLE 6—*Analyses from trial pits, Bababudan Iron Ores (dried at 100° C).*

Serial No.	Registered numbers	H_2O	SiO_2	Al_2O_3	Fe	Mn	S	P	TiO_2	Remarks
14	S_2/493a	6·9	0·77	9·82	58·37	0·06	0·047	0·057	...	Pit ¼ mile N.-W. of Kalhatti bungalow.
15	S_2/493c	9·94	1·50	6·99	55·39	0·10	0·048	0·105	...	Vesicular limonite } Pits on scarp overlooking Santaveri.
16	S_2/495	4·39	1·32	1·18	65·11	trace	0·027	0·069	...	Chiefly hæmatite } Pits on scarp overlooking Santaveri.
										Pits on Kemmangundi ore field.
17	S_8/80	...	0·80	...	61·49	trace	trace	0·112	Nil	Spongy surface crust, mostly limonite.
18	S_8/92	...	1·97	0·79	51·40	0·21	0·099	9·105	1·00	Spongy surface crust, mostly limonite.
19	S_8/82	...	0·61	...	64·25	0·120	0·021	0·052	trace	Harder hæmatite bands below crust.
20	S_8/84	...	1·43	...	57·72	0·15	0·061	0·053	trace	Harder hæmatite bands below crust.

TABLE 6—*Analyses from trial pits, Bababudan Iron Ores (dried at 100° C).—concld.*

Serial No.	Regis-tered numbers	H_2O	SiO_2	Al_2O_3	Fe	Mn	S	P	TiO_2	Remarks
21	S_3/83	...	0·46	...	61·88	0·069	trace	0·099	0·96	Mixed small ore. Sorted out from pits.
22	S_3/93	...	1·07	8·30	56·50	0·20	0·044	0·086	0·73	
23	S_3/94	...	1·81	11·25	55·75	0·17	0·055	0·090	1·50	Thin banded ore.
24	S_3/76	..	3·71	...	63·73	0·134	Nil	0·069	trace	Softish red and black hæmatites (40 %).
25	S_3/90	..	9·56	0·62	42·40	0·30	0·059	0·122	0·70	Fines left after sorting out No. 24 (60 %).
26	S_3/77	...	3·89	...	54·95	0·11	0·022	0·061	trace	Lumps and pebbles in alluvium valley.
27	S_3/78	..	1·32	...	61·18	0·130	0·028	0·072	trace	
28	S_3/79	...	2·66	...	56·43	0·160	0·013	0·092	trace	
29	S_3/89	...	1·46	0·51	56·30	0·21	0·076	0·120	0·82	Samples of waste dumps from which the harder lump ore had been sorted out.
30	S_3/91	...	1·96	10·61	44·80	0·23	0·180	0·121	0·55	
31	S_3/95	...	1·44	2·25	55·25	0·03	0·047	0·120	0·80	

Replacement Ores.

The more valuable bands of harder hæmatite and limonite occur in a banded series overlying the ferruginous quartzites and from the evidence obtained in a number of prospecting pits the series was probably originally composed of bands of mica-chlorite schists and chloritic and hornblendic trap. Their original character can only be surmised as they are now completely converted into banded iron ores and ochres with varying bands, etc., of harder hæmatites and limonites. The hardened bands give bold outcrops between which much of the surface presents an indurated crust, 2 to 5 feet thick, beneath which the more finely banded ore and ochre is comparatively soft. The original rocks appear to have been completely altered by removal of the silica, lime and magnesia, very little of which remain, and the concentration of the iron. The harder bands of hæmatite and limonite are probably those in which there has been considerable deposition of iron from solution over and above the general concentration effected by metasomatic replacement, and in some cases the hardened hæmatite has been observed to penetrate the banded ores and ochres in branching veins transverse to the banding.

The Crust.

The harder crust, much of which is fairly good ore though often somewhat high in phosphorus, gives a deceptive impression of the amount of smelting ore available; for, on being broken through, it passes into soft banded ores and ochres of which probably 50 per cent would have to be rejected as too fine and soft. Such rejectable material is represented by the waste dumps from the pits at Kemmangundi (analyses 29, 30 and 31) which probably average from 50 to 55 per cent of iron and about 0·12 per cent phosphorus. Samples of the crust 4 to 8 feet thick are represented by analyses 14, 17 and 18 containing from 51 to 61 per cent of iron with about 0·1 per cent phosphorus and a good deal of combined water. Nos. 17 and 18 are mostly vesicular limonite and No. 14 chiefly hæmatite.

Lateritoid.

In low lying places especially where the crust has been denuded or much altered by water we get a highly vesicular or lateritoid [1] layer developed on top of the banded ores and even passing downwards between the harder bands, which are sometimes broken up into fragments by gradual subsidence and collapse. One such place is at the road cutting at the western end of the Kemmangundi field where a face of 10 feet of finely banded ore and ochre gave analysis 5 and the lateritoid layer over it, into which it appears to have altered, gave analysis 6. These are reproduced below for comparison showing the increase in alumina and the marked increase in phosphorus:—

	SiO_2	Al_2O_3	Fe	Mn	S	P	TiO_2
No. 5 ...	3·63	6·56	55·11	0·80	0·052	0·044	...
No. 6 ...	3·23	10·04	48·08	...	0·087	0·244	1·05

Earthy Hæmatites.

In one of the pits at Kemmangundi rather soft and earthy or stony looking red to black ore was met with for a depth of 9 feet. It is compact, non-banded and breaks with conchoidal fracture into lumps and small fragments and is suggestive of a completely altered band of trap. Of the material excavated 40 per cent was sorted out as lump ore 2 to 3 inches and over. This gave analysis No. 24 with nearly 64 per cent of iron and would form a valuable ore if it will stand transport. There is probably a large body of it. The remaining 60 per cent is inferior and contains much more silica and phosphorus but can be readily sorted out.

The harder lump Ore.

These are the best and most valuable portions of the series and include the outcrop blocks and the harder bands below surface. The analyses given show their character.

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(1) 'Lateritoid' is a term suggested by Dr. Fermor to denote highly vesicular ferruginous material having somewhat the aspect of laterite though not sufficiently similar to typical laterite to permit of the latter term being employed or generally admitted. *Vide* "The Manganese Ores of India" by L. Leigh Fermor, D.SC., A.R.S.M., Memoirs of the Geological Survey of India, Volume XXXVII, p. 383.

TABLE 7—*Analyses of Iron Ores from various localities.*

Serial No.	Regis-tered numbers	H_2O	SiO_2	Al_2O_3	Fe	Mn	S	P	TiO_2	Remarks
32	S_2/747	...	1·80	...	60·04	...	0·027	0·10	...	Limonites from Shankargudda associated with manganese ores.
33	..	...	2·76	...	52·80	8·5	...	0·089	...	
34	...	...	8·10	2·62	54·20	0·78	0·015	0·022	0·03	Limonite from Kumsi, combined water=10·05 %.
35	J_4/117	1.23	0·88	1·79	56·82	0·38	0·049	Nil	11·60	Titaniferous ore from Ubrani contains 3·09% Cr_2O_3.
36	O/271	...	0·52	1·93	61·44	0·416	0·024	Nil	10·21	Titaniferous magnetite, Tagadur, contains 1·21% Cr_2O_3.
37	...	...	0·44	Nil	65·64	0·296	0·017	Nil	5·17	Magnetic concentrate from No. 6 =81·31% of the whole.
38	...	...	0·84	9·65	44·64	0·89	0·052	Nil	30·37	Non-magnetic residue from No. 56 (calculated).
39	...	...	13·82	Nil	61·36	0·224	Nil	0·022	trace	Magnetic concentrate (45·56%) from quartz magnetite ore of the charnockite series (O/261).

The following remarks refer to the Kemmangundi area. Analyses 1 to 4 are from the main scarp over a length of 1,000 feet or so. 7 to 10 are from central outcrops and 11 to 13 are from a new deposit, a mile further north and close to the gorge leading through the outer escarpment of the Bababudans to the low country. All of these are outcrop samples and run from 61 to 65 per cent iron and about 0·02 to 0·05 per cent phosphorus. No. 19 represents bands of hard hæmatite at a depth of 13 feet but sufficient work has not been done to show how numerous these bands are or to what extent the heavier outcrops continue downwards.

In the valley in the middle of the deposit there is alluvial soil underneath which is a considerable thickness (14 feet in places) of pebbles and small boulders represented by analyses 26 to 28.

Quantity of Ore.

The foregoing account shows the very complex character of these deposits and without much further deep prospecting and sorting it is impossible to speak very definitely about quantities and grades. The following estimates refer only to the Kemmangundi field and must be regarded as tentative and are, we believe, conservative.

The area of the ferruginous deposits on the Kemmangundi field is almost 50 acres and the conditions noted as occurring beneath the surface crust may be expected to continue to depths of 50 feet and probably more.

If we take an average depth of 25 feet the total tonnage would be nearly 4,000,000 allowing 2 tons per cubic yard, and the average composition about the following :—

(*a*) Iron–57 per cent; Silica–2 per cent; S–0·05; P–0·08.

About 50 per cent would have to be rejected as too fine and soft for blast furnace work and the remaining 50 per cent would be rather better throughout than the above average.

This would give some 2,000,000 tons of usable ore out of which we might expect to get—

(b) 500,000 tons running 61 to 62 per cent iron and 0·05 per cent phosphorus.

(c) 1,500,000 tons running 56 to 57 per cent iron and 0·09 per cent phosphorus.

From the smaller deposit, about 30 acres in extent, near the gorge about 1 mile north of the former, we might expect at least half these quantities, but as this has not been prospected yet this is merely a general assumption.

However from these two deposits we might expect three quarters of a million tons with 0·05 per cent phosphorus and some two million tons with about 0·09 per cent of phosphorus or rather less.

These are only two deposits out of a large number in the whole area situated at distances of from 1 to 10 miles from this point over rough hilly country.

Cost of Ore.

Until more is known about the sub-surface distribution of the harder and better ore we cannot be very precise as to costs. They must be adversely affected by the roughness of the ground and by the fact that work will not be possible for more than five or six months in the year owing to the heavy monsoon conditions.

If we assume that excavation and sorting will cost on an average Rs. 2-8-0 to 3-0-0 per 100 cubic feet and that from this we get 1 ton of the better ore (b) this gives Rs. 2-8-0 to 3-0-0 per ton of ore.

If this grade only was required the surface outcrops would be taken and excavation confined to the heavier bands or zones in which we might expect some 3 tons per cubic foot. This would reduce the above charge to from As. 13 to Re. 1. If in addition, as is quite probable, an equal quantity of ore of class (c) was also required the charge would come down still lower. Adding supervision and royalty we might consider that the cost will probably be between 1 and 2 rupees per ton according to the grade demanded and for subsequent estimate we will assume the higher figure.

The ore will have to be taken down the steep Kemmangundi gorge, probably by a wire ropeway, and thence by a light railway to a smelting works at Benkipur or Shimoga for which a transport charge of Re. 1 per ton may be added making the cost Rs. 3 per ton at the works with possibilities of some reduction.

LIMONITE ORES IN THE SHIMOGA DISTRICT.

Some fairly extensive outcrops of limonitic ore have been found in the Shimoga District in the altered ferruginous schists and ochres which carry the manganese deposits.

Three analyses of these are given in Table 7 of which Nos. 32 and 33 are from Shankargudda and contain nearly 0·1 per cent phosphorus. No. 34 from Holmes' Block near Kumsi shows that in some cases these ores are fairly low in phosphorus (0·02 per cent) and further prospecting may disclose some valuable bodies of such ore which would be of great value with charcoal fuel for production of low phosphorus irons.

CHITALDRUG SCHISTS.

Considerable bodies of soft limonite ores with some bands of harder hæmatites occur in parts of the Chitaldrug schist belt especially towards the western side in the neighbourhood of Karekalgudda, Bodimaradi and Chiknayakanhalli. Many of them are too soft and friable for furnace work, but considerable spreads of surface boulders of the harder hæmatites occur in places. These ores are far away from the railway and from fuel or any possible smelting site and have not been closely examined at present. Their use would be justified only if they possessed special qualities not obtainable as easily elsewhere.

QUARTZ MAGNETITE ORES OF THE CHARNOCKITE SERIES.

These have been found south of Halagur in the Malvalli Taluk not far from the Cauvery Falls. A couple of runs or dyke-like veins of these extend for a couple of miles north and south and are 10 to 15 feet thick. They are composed essentially of quartz and magnetite with subordinate amounts of hypersthene, amphibole, and garnet. They would require to be crushed and magnetically concentrated.

Tests with a hand magnet gave 45·56 per cent of concentrate containing 61·36 per cent of iron and 0·022 per cent phosphorus when crushed through 30 mesh; (Analysis 39). When crushed through 60 mesh the results were:—

Concentrate = 54·95 per cent containing 66·37 per cent iron and 8·36 per cent insoluble residue.

It is not considered that these ores are of value at present. What the results of commercial concentration would be are not known, but the ferruginous silicates present will render it difficult to obtain a very clean product and the cost of the concentrated ore will be high—probably at least Rs. 7 to 8 per ton at the mines.

TITANIFEROUS IRON ORES.

A large number of outcrops have been found in the neighbourhood of Ubrani to the north of Tarikere and also in the Nuggihalli schist belt near Tagadur—south of Tiptur. They were investigated as possible sources of high class magnetites and hæmatites, but analyses showed the presence of much Titanium which renders them unsuitable for smelting work though they may possibly be of use in a small way for production of special titanium steels. Analyses 35 to 39 show the composition of these ores and of the magnetic concentrate and residue from those near Tagadur.

POSSIBILITIES OF UTILIZING THE ORES.

Indigenous Smelting Industry.

Iron smelting on a small scale has been carried on in most parts of the State in past times as witnessed by the numerous slag-heaps most of which mark the sites of abandoned works. A few furnaces still exist but are hardly ever used and the industry may be said to be extinct. The processes of work, which have been described frequently, consisted in the smelting of selected ore with charcoal in small furnaces a few feet in height. A blast is obtained by means of skin bellows and the result is the accumulation of a more or less melted mass of iron and slag—which is called a "bloom"—in the hearth of the furnace. The bloom is withdrawn, reheated and hammered to weld it into a solid mass and to remove slag and cinder. It is cut up into convenient pieces of "wrought iron" from which implements are forged. When steel is required the wrought iron is cut into small pieces of $\frac{3}{4}$ lb. weight and each piece put in a crucible with some charcoal and bits of wood and leaf of the *Thangadi* plant which is supposed to possess special virtue for the process. The crucibles are sealed up with clay and heated in a charcoal hearth for 5 hours with the result that the iron absorbs carbon by a sort of cementation process and is converted into steel.

The steel produced is variable in character but often of high quality. The processes are wasteful and expensive compared with modern methods.

The operations have been examined and reported upon by various officers, but it is very difficult to arrive at any satisfactory estimate of costs.

The following statement gives the average consumption of materials as reported:—

	Wrought Iron tons	Iron Bloom tons	Iron ore tons
1 ton of steel requires	1·1 to 1·5	2 to 2·7	About 11·5
1 ton of wrought iron requires.	1	1·8	3·6 to 6·48
1 ton of iron bloom requires.	...	1	2 to 3·6

As regards the *charcoal* :—

To make 1 ton of bloom from ore requires 3 tons of charcoal.

,, 1 ton of wrought iron from bloom requires 1·75 tons of charcoal.

,, 1 ton of steel from wrought iron requires 3·25 tons of charcoal.

Therefore to produce 1 ton of wrought iron requires altogether 8 tons of charcoal,

and 1 ton of steel requires altogether 12 tons of charcoal.

As regards *costs* it may be noted that the ore is allowed to be taken free, charcoal is either free or a small seigniorage of about Rs. 3 per ton is charged and sometimes a yearly tax of from Rs. 5 to 12 per furnace was imposed. These very variable charges are *omitted* in the following estimates which are based simply on the labour required for collecting the materials and conducting the smelting operations: the wages quoted are very low, *viz.*, Rs. 40 to 50 per year per man, or considerably below present day rates. Under these conditions the averages of the various estimates which have been made come out as follows :—

Wrought iron.—	Calculated cost	Rs. 150 per ton
	Selling price	Rs. 260 do
Steel.—	Calculated cost	Rs. 490 per ton
	Selling price	Rs. 723 ,,

Apparently the work should be very profitable but the selling price is based on the reported value of small pieces sold locally and occasionally and cannot be considered as representing a fair or fixed market rate. The fact that all the furnaces have been moribund or closed down for some years past must, we think, be attributed to the fact that the material cannot be sold at a profit in competition with imported iron and steel which can now be easily obtained for less, not only than the selling prices given above but in most cases for less than the calculated costs of production. These latter costs would be, we believe, materially increased if recalculated on present day rates of wages and the chances of resuscitating the industry on a profitable basis appear to be definitely removed even allowing the ore and charcoal to be taken free.

EXPORT OF ORE.

The prospects of exporting the ores from the Bababudans are not favourable at present. If we consider the deposits at Kemmangundi and others within a couple of miles, such as those along the scarp overlooking Santaveri and those around the south and west flanks of Kalhattigiri, we may expect to obtain several million tons of ore running 57 to 60 per cent of iron, 0·05 per cent phosphorus and 2 per cent or less of silica and the value of such ore would probably be Rs. 15 to 17 per ton in England. The phosphorus is the most important factor and the value of the ore would increase or decrease with this element.

If we assume that this ore can be put on the railway at Shimoga at Rs. 2 to 3 per ton and that it can be put on board ship at a port on the West Coast (Bhatkal for instance) for another Rs. 2 we may take the cost f.o.b. Bhatkal at about Rs. 5 per ton leaving from 10 to 12 rupees for freight to England. This is rather below what freights have been in the past and the ore would probably cost one or two rupees per ton more than it could be sold for. The English prices may increase from time to time and mining costs may be somewhat reduced and there is some possibility that both ends could be made to meet especially in the case of a company which required the ore for its own use and not for sale; but it is obvious that it will require favourable circumstances and careful management to effect even this. Some of the other ores in the Shimoga District may prove to be better placed and permit of a reduction of the mining and transport charges to the extent of one or two rupees per ton and it is likely that some suitable ore may be found along the Western Ghats along certain tracts on the west of the Shimoga District which have not been examined yet and which would be much nearer to the port. Neither the port nor the railway exists at present and export is a question of the future and the above figures are given merely to indicate the principal factors so far as our present information goes.

SMELTING IN MODERN BLAST FURNACES.

The ores of Mysore are sufficiently abundant and of good enough quality to be suitable for the manufacture of pig iron on a considerable scale, but unfortunately the supply of fuel is either too limited or too costly to permit of this being undertaken except within certain narrow limits. The fuel required is either coke or charcoal and the position with regard to these will be explained very briefly.

Smelting with coke.—As there is no coal in Mysore it would be necessary to import either coal or coke and we may take it that coke will cost over Rs. 30 per ton and will be considerably more expensive than charcoal. The pig iron would probably cost about Rs. 55 per ton or about $2\frac{1}{2}$ times as much as at the Tata Iron Works at Sakchi where coke can be obtained at some Rs. 7 per ton. The pig iron so produced would be similar to that made at Sakchi and it would be impossible to sell the Mysore iron in competition with either the Tata iron or imported iron except within a very limited distance from the works and the very small demand within such limited area, say a few hundred tons a year, is too small to make the work possible at a profit. Good imported iron is quoted at Rs. 60 to 65 at Indian ports and probably sells at Rs. 65 to 75. These prices could probably be reduced and the Tata pig iron could obviously be sold for considerably less, even in the south of India. It is obvious that Mysore pig iron costing some Rs. 55 at the works, nearly all of which would have to be sent to distant markets for sale, could not compete against these outside rivals.

It may be worth while however to note that the opening of a port on the coast west of Shimoga would reduce the cost of coke and that this might reduce the cost of the pig iron to Rs. 45 or even less. Even then there would be little chance for the sale of any considerable quantity and the fact is merely noted for reference in connection with the preparation of steel which will be discussed later.

Smelting with charcoal.—This stands on a different footing from smelting with coke. Indian coke is fairly impure and contains 14 to 15 per cent of ash and the ash contains about 0·9 per cent of phosphorus practically all of which gets into the finished pig iron.

Charcoal on the other hand is free from both ash and phosphorus and the pig iron produced is usually of a higher grade than coke pig and sells at a higher price. Swedish charcoal pig costs about Rs. 75 f.o.b. Sweden, and would probably be worth Rs. 90 to 100 in Indian markets. At present very little is used in India but there is every reason to expect that a small output could be disposed of in India, Japan and Australia and that an industry could be developed in the manufacture of special castings for which charcoal pig is required —such as engine cylinders, chilled car wheels, rolls, etc. We may therefore consider the amount of charcoal pig which can be produced and its cost.

Charcoal.

The amount which can be produced is limited by the steady supply of charcoal which can be obtained from the forests without permanent depletion. The Conservator of forests has estimated recently that an annual supply of 20,000 tons of charcoal could be maintained from the forests of Kadur and Shimoga. In order to obtain this about 100,000 tons of suitable wood would have to be collected annually from forests spread over a large area and it would be necessary to provide 150 to 200 miles of light railways or tramways to collect the wood and bring the charcoal to a smelting work situated, let us say, at Shimoga. The Conservator estimates that the charcoal could be delivered at Rs. 25 per ton. We may accept these figures for a provisional estimate though we are inclined to regard them as conservative and any increase in the supply or reduction in cost would tend to lower the cost of the smelted iron.

Smelting Plant.

With 20,000 tons of charcoal we can produce some 20,000 tons of pig iron and for this we might use three small furnaces of the Swedish type or one large furnace of the American type. The latter, if equally suitable in other respects, would be the more economical.

The furnace with its accessories in the shape of hot blast stoves, blowing engines, cranes, ladles and buildings would cost about 9 lakhs of rupees on which interest and depreciation at 10 per cent would come to Rs. 4·5 per ton on an output of 20,000 tons.

The costs of manufacture may be apportioned as follows, approximately :—

Cost of making Charcoal Iron.

Output 20,000 tons per annum.

1·65 tons of ore (Fe—60 per cent) at Rs. 3 per ton	...Rs.	4·95
1 ton charcoal at Rs. 25 per ton ...	... ,,	25·00
5 cwts. limestone at Rs. 5 per ton ...	... ,,	1·25
Lining and repairs to furnace ...	... ,,	1·50
Interest and depreciation (10 per cent) ...	... ,,	4·50
Supervision, labour and other charges ...	... ,,	8·00
Total cost per ton of pig iron	...Rs.	45·20

According to these figures we can make charcoal pig iron at about Rs. 45 per ton and it is probable that some of the items can be reduced in practice and that we might hope to get down to Rs. 40 or even a little less.

In the absence of an existing demand and reliable quotations for this class of material it is very difficult to say what the value of the product would be at the works, but it is probable that it would be worth from Rs. 55 to 70 per ton. At an average of Rs. 60 it might be regarded as sufficiently attractive and there is a fair prospect that parts of the output made from specially selected ores and sold for special purposes would fetch considerably more.

The sale of pig iron is however only part of the scheme which contemplates the conversion of about half, or 10,000 tons, into steel. The remaining 10,000 tons would partly be sold as pig and partly made into castings for special purposes on which work an additional profit might be expected. As will be shown later, the steel-making portion may be expected to be feasible and profitable and without allowing for very special grades and special prices the work as a whole may be expected to yield a fair profit on the output of 20,000 tons with considerable prospects of increase from the development of special lines of work.

Before passing on to the question of steel-making we may very briefly consider the possibilities of smelting the ores electrically instead of depending entirely on our limited supplies of charcoal.

ELECTRIC SMELTING OF ORE.

Suggestions that electricity should be used for the smelting of iron ore and other metallurgical purposes are very popular in Mysore and a few words as to the comparative values of electricity and charcoal fuel may not be out of place.

The generation of electric power from waterfalls in Mysore is by no means very cheap. The water going over the falls is very variable and is reduced to comparatively small amounts during the dry months. Metallurgical industry requires, as a rule, a constant supply of power throughout the year and if a large amount is required it becomes necessary to provide large storage reservoirs for the excess water which runs to waste during the rains and this means added expense.

For the supply of power on a large scale the cost of generating the current is not likely to be less than 0·1 anna per unit (Kilo-watt-hour) and where the power has to be transmitted to a smelting works at a considerable distance from the generating station the cost is not likely to be less than 0·2 anna per unit delivered at the works. Under certain favourable conditions a company might be able to obtain supplies from moderate distances (50 to 100 miles) at 0·15 anna, but it must be remembered that the maximum amount which has to be provided for is not used continuously throughout the year and for the purpose of making a comparison we will take the minimum cost for the power actually consumed at 0·2 anna per unit which is at the rate of Rs. 81 (£5-7-6) per Horse-Power Year.

In any specific case the actual rate quoted or estimated can be readily substituted for this figure.

In Norway and Sweden the work of recent years has shown that from 2,000 to 2,500 K.W. Hours are required to produce 1 ton of pig iron from iron ore. With the Mysore ores containing 60 per cent of iron it is probable that the figure would be about 2,500 K.W.H.

In addition about 7 cwts. of charcoal will be required to reduce the oxides of iron to metallic iron.

About 15 or 16 lbs. of carbon electrodes will be required per ton of iron and these will cost about 3 annas per lb. or Rs. 3 per ton of iron. Leaving out other charges we can now compare the relative costs of charcoal and electric energy :—

	Rs.
To produce 1 ton of pig iron by charcoal smelting requires 1 ton of charcoal costing	25

To do the same work electrically we require—

2,500 K.W. Hours at 0·2 anna ...	31·25
7 cwts. charcoal at Rs. 25 per ton...	8·75
16 lbs. of electrodes at 3 annas per lb.	3·00
Total	43·00

Electricity is obviously much more expensive than charcoal. In order to make the former equal the latter it would be necessary to reduce the charge for power by Rs. 18, (43—25) in which case 2,500 K.W. Hours would cost Rs. 13·25 which is at the rate of 0·085 anna per unit which is, we believe, considerably below the cost at which it is possible to generate it in Mysore.

At the rate of 0·2 anna per unit adopted above we may estimate the cost of smelting 1 ton of pig iron electrically as follows for an output of 20,000 tons per year:—

	Rs.
1·65 tons of ore at Rs. 3 per ton	4·95
7 cwts. charcoal ,, 25	8·75
7 cwts. limestone ,, 5	1·75
Electrodes 16 lbs. at 3 annas per lb. ...	3·00
Electric power 2,500 K.W.H. at 0·2 annas	31·25
Repairs and relining	2·00
Interest and depreciation	4·50
Supervision, labour and other charges ...	9·00
Total per ton of iron Rs.	65·20

This is very much higher than the estimate of Rs. 45 for iron smelted in charcoal furnaces, and even with electric power at 0·1 anna per unit the cost would still be higher, *viz.*, Rs. 50 or thereabouts. The plant for this work would cost about 9 lakhs of rupees and include 3 furnaces of 3,500 horse-power each requiring about 7,000 horse-power to run.

Under existing conditions the electric smelting of the ores appears to be out of the question not only because it is more expensive than charcoal smelting but because the actual cost per ton (Rs. 65) appears to be too high to permit of the iron being sold at a profit.

STEEL-MAKING.

For the manufacture of steel we believe that it will be quite feasible to use electricity even though the latter may cost more than 0·2 anna per unit and as a convenient figure on which to base estimates we will adopt a rate of 0·3 anna per unit equivalent to Rs. 123 (£8-4-0) per Horse Power Year.

Steel direct from Ore.

It is possible to make steel direct from the ore—that is without making pig iron first and this has been discussed in Bulletin No. 5.[1] On the assumptions then made, with power at rather less than 0·1 anna per unit it was argued that the cost of steel might come down to from 83 to 105 shillings per ton according to scale of output. With figures now available and making 10,000 tons per annum from 60 per cent ore with power (3,000 K.W.H.) at 0·2 anna the cost would be about Rs. 100 (133 shillings) per ton. The direct process is practically not in use and is not favourably regarded by most metallurgists and we can work cheaper by indirect methods.

Steel from Pig Iron

We have estimated that it costs Rs. 45 per ton to make the pig iron in charcoal furnaces. For the purpose of conversion to steel it would be perferable to make a *white* iron rather than ordinary foundry pig and this could probably be done somewhat more cheaply, say, at Rs. 40 per ton, and we shall adopt this figure.

The pig iron contains a little over 3 per cent of carbon and to make steel this has to be removed and the metal re-carburized so as to contain from 0·06 to 1·5 per cent of carbon according to the character of the steel required. At the same time impurities such as phosphorus and sulphur are removed. In order to save the cost of remelting the pig iron it is advantageous to have the refining furnaces close to the blast furnaces so that the molten pig iron may be transferred from the latter to the former without being allowed to cool or solidify. The molten pig iron might be poured, from a ladle directly into the electric furnace and there refined by adding iron ore, which would oxidise or burn out the carbon, but such

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(1) Notes on the Electric Smelting of Iron and Steel by W. F. Smeeth, M.A., D, SC., etc., Bulletin No, 5—Mysore Geol. Dept.

a process takes time and involves much consumption of electric energy.

A better scheme is to pour the molten pig iron into a mixer or converter and blow air through it, thereby getting rid of the carbon and effecting a partial refining. This partially refined metal is transferred to the electric furnace with the addition of fluxes and the refining completed. The metal can be brought to almost any desired degree of purity. The consumption of energy depends on the impurities present and on the degree of purity required and the figures given below are based on the average conditions which may be expected to obtain in the production of high-class carbon steels.

Without entering into the question of the type of furnace, we may take it that for an output of 10,000 tons of refined steel 2 furnaces of 5 tons capacity each will be required, one being held in reserve for the greater part of the time. The furnaces with their accessories will cost about Rs. 1,50,000, and the electric current can be generated at the works from the waste gases of the charcoal furnace.

The following figures are based on European practice :—

		Rs.
Cost of molten pig iron at Rs. 40 per ton	...	40·00
Cost of partial refining in converter	...	10·00
Oxidation loss	...	1·50
Electric power for refining, 200 K.W.H. at 0·3 anna per unit	...	4·70
Electrodes	...	1·25
Repairs and tools	...	2·00
Fluxes and ferro-additions ...	...	3·00
Interest and depreciation (10%) ...	...	1·50
Supervision and labour ...	...	3·00
Royalty, not included ...	...	...
Total per ton of steel	...	66·95

The molten steel will therefore cost about Rs. 67. If there is much refining to be done the cost for power will go up, but it is reasonable to assume that we should be able to make steel suitable for high-class forgings, castings and tools at an average of from Rs. 67 to 75 or say for £4-10-0 to £5 per ton. The cost of converting the molten pig-iron to steel is therefore Rs. 30 to 35 per ton.

Steel from Scrap.

At the works, especially if casting, forging and machining is carried on, a good deal of scrap will be produced and this would provide additional work for the electric furnaces. In addition, it should be possible to purchase a certain amount of wrought iron and steel scrap from railways, workshops, etc. The amount obtainable is not very large and would depend on the price that could be paid. We believe that it should be possible to obtain some 2,000 tons a year at a cost of Rs. 30 per ton and that the cost of melting and refining this would be about Rs. 30 or less. This would give an additional output for the furnaces and every addition means decrease in standing charges.

Small Plant.

It may be noted that a small independent plant could be run on scrap for a production of about 2,000 tons a year using a $2\frac{1}{2}$ ton furnace. The costs would of course be higher than if the work was combined with the larger iron and steel plant described above and there would not be room here for both. It is however an alternative in case the iron smelting scheme is not taken up. The cost of the steel would be in the neighbourhood of Rs. 70 to 75 per ton and the subsequent operations of casting, forging, etc., would all be more expensive on the smaller scale.

Value of Products.

It is a difficult matter to assess the value of the products from the steel works. Much depends on the grade of materials produced and on the development of markets. The materials would all be of comparatively high grades which are not being made in India at present, such as axle and tyre forgings, high-class steel castings, tool steel and steels for drills, jumpers, etc. Ordinary steels for rails, bars, sheets and rolled sections would be out of the question in comparison with similar materials made in India or imported. The market in India for the higher class products is comparatively limited and we should probably have to seek outlets in the Straits, China, Japan and Australia.

The following figures are very tentative :—

Output of 2,000 tons per annum.—The products of the small scrap plant might be divided into 1,500 tons of forgings, castings, etc., valued at Rs. 180 per ton and 500 tons of tool and bar steel valued at Rs. 250 per ton.

With steel ingots costing Rs. 75 and allowing for expense of manufacture the former would cost about Rs. 140 and the latter about Rs. 170 per ton. We thus get the following estimate :—

1,500 tons forgings, etc., valued at Rs. 180 = Rs. 2,70,000.	Cost at Rs. 140 = Rs. 2,10,000
500 tons tool and bar steel valued at Rs. 250 = Rs. 1,25,000.	Cost at Rs. 170 = Rs. 85,000
	Balance Rs. 1,00,000
Rs. 3,95,000	Rs. 3,95,000

This balance would have to cover part of interest and depreciation, and management and should leave a very fair profit.

Output of 11,000 tons per annum.—For the larger plant using steel converted from charcoal iron as well as scrap we might take the cost of the ingot steel at Rs. 70, cost of forgings, etc., at Rs. 120, cost of tool and bar steel at Rs. 150 and get the following :—

11,000 tons castings, forgings, etc., valued at Rs. 175 = Rs. 19,25,000.	Cost at Rs. 120 = Rs. 13,20,000
1,000 tons tools, bar, etc., valued at Rs. 200 = Rs. 2,00,000.	Cost at Rs. 150 = Rs. 1,50,000
	Balance = Rs. 6,55,000
Rs. 21,25,000	Rs. 21,25,000

The balance would have to cover interest, depreciation and management not already provided for and expenses of sale and a large proportion of it should be available for profit. The sale values depend on the quality of the products and the market demand for them and the figures adopted will be found, we believe, to err on the low side. There is little doubt about our being able to produce high quality and the only serious difficulty will be the finding of markets for the products at their proper values. High-class castings and forgings should be worth considerably more than Rs. 175 per ton and such items as tool steel, mining drills, jumpers, etc., should be worth Rs. 300 to 400 per ton. If markets are developed so that a considerable proportion of the output can be sold at the higher figures the profits would increase enormously and that is the prospect which we contemplate as eventually possible. On the other hand, there will be undoubted difficulty in securing these sales at first and much of the output may have to be got rid of at comparatively low prices in competition with poorer grades of material or to cover the expense of transport to distant markets and in view of this the average sale values have been estimated at fairly low prices. This is however largely conjectural and we cannot go into the matter more fully here; we have given our facts and assumptions and people with a knowledge of the business side can alter the items according to their knowledge and experience.

SUMMARY.

We have endeavoured to show that large quantities of good smelting ore are obtainable at a reasonable cost from the Bababudan Hills. There are some indications that better class ores, particularly in regard to lower contents of phosphorus, may be obtainable in parts of the Shimoga District. These have not been located yet in any considerable quantity, but the question is one of very great importance as the value of the ore and the profits to be derived from the finished products would be increased very materially if the phosphorus could be kept low, say below 0·02 per cent. The resources of the forests would appear to permit of the smelting of some 20,000 tons of iron per annum of which half might be sold as charcoal pig iron or made into special castings and the other half converted to high grade steel in electric furnaces.

To establish an industry of this size some 50 lakhs of rupees would be required of which 20 lakhs would be required for the iron and steel works and 30 lakhs for the charcoal kilns and light forest railways for collecting fuel and bringing in charcoal and ore. The 20 lakhs or so for the light railways would not be needed all at once, but could be called up as extensions are required for tapping the various forests.

The establishment of such an industry would have far reaching consequences and would materially assist in development of local manufacturing and industrial work. The figures we have given encourage the view that the work would be profitable and if the finished products of really high grade can be maintained the profits should be materially increased. It cannot be too strongly insisted upon that the objects of the scheme should be to make and sell only high grade materials and that in view of the comparatively small scale of operations, the high price of fuel and the absence of a local market it would be quite impossible to compete in the ordinary grades of commercial iron and steel which are now being made in India or imported.

The establishment of a new industry in a new place and under untried conditions always involves many doubtful and difficult problems, and while recognizing this clearly we are still of opinion that a successful and profitable industry can be developed on the lines indicated provided that thoroughly experienced supervision and business capacity is provided and that the sympathetic co-operation of Government is secured for the regular supply of charcoal and other facilities.

Manganese.

MANGANESE ORES.

Distribution.

The manganese ores appear to be confined to the Chloritic or Upper Division of the Dharwar Schists. None has been found in the Hornblendic Division. The ores are found in the Shimoga, Kadur, Chitaldrug and Tumkur Districts and their distribution is shown on the map by square dots. The dots represent deposits or groups of deposits where appreciable quantities of ore have been found, even though it may not have been found possible to work them commercially owing to the grade being too poor. In Table 8 a list is given of the principal deposits or localities where ore has been mined and the quantities exported to the end of 1914. In several cases no exports have been made, but ore has been mined and stacked which is either too poor to export or is awaiting more favourable market rates.

From the map it will be seen that most of the deposits are confined to two divisions, *viz.*—

(1) the *Shimoga Division* in which the deposits are situated in the schists surrounding the large mass of the Shimoga gneissic granite; and

(2) the *Chitaldrug Division* in which the deposits lie near the western edge of the Chitaldrug schist belt in the Chitaldrug and Tumkur Districts.

In addition, some isolated deposits have been found near Hoskere and Halekal from which small quantities of ore have been obtained.

In the Shimoga Division some of the most important deposits are situated along the crest of Shankargudda ridge from 1½ to 3 miles south of the △3393. For some years after their discovery by Mr. Slater the results obtained were poor. Deeper work during the past two or three years has shown that the deposits are fairly large and there are indications that several hundred thousand tons of marketable ore will be obtainable. The character of the ores is shown by the analyses in Table 11.

Further south along the ridge at Adgadde and Hemmaki (near Mandagadde) small deposits of ferruginous ores have been found.

In the large area of schists to the west of the Shankargudda ridge low grade ores have been found near Aranelli, Karkodlu and Puradkoppa most of which are high in iron and phosphorus. This area is worth further prospecting, but the heavy jungle and soil will render the location of deposits a matter of considerable difficulty and expense.

Passing northwards a small amount of ore has been obtained near Choradi and some very ferruginous ores mixed with limonites at Tuppur, about 5 miles west of Choradi.

To the north of Kumsi the schists swing round eastwards and the important deposits at Holmes' pit and Python lie about 4 miles N.N.E. of Kumsi. Over 200,000 tons of ore have been exported from Holmes' pit and there is still a large quantity to be obtained though the ore bodies appear to be petering out at a depth of 80 feet from surface.

The Python pits lie about a mile east of Holmes' pit and are expected to yield a fair quantity of 1st and 2nd grade ore. It is probable that other deposits will be found in this neighbourhood, but soil and jungle render their location difficult. The deposits at Holmes' pit and Python were searched for and prospected for several years before the ore bodies were located. A little to the east of Python the schists swing north again and we come to a series of small deposits lying round the north of the Saulonga granite in the Shikarpur Taluk. These are situated in groups near the villages of Markande, Ittigehalli, Hosur and Ballur and some ore has been reported from the neighbourhood of Kaginelli.

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TABLE 8.—*Localities of the principal deposits of Manganese Ore.*

Taluk	Locality	No. of license or lease	Holder of current license or lease and number	Quantity exported Tons
	SHIMOGA DISTRICT.			
Shikarpur ...	Ittigehalli	P. L. 93 ...		
	Hosur and Ballur	,, 99 ...		
	Kaginelli, N. of Ballur	,, 110 ...		3,003
Kumsi (Sub-Taluk)	Holmes' block, Kumsi (includes Holmes' pit, Python and Sigimatti).	M. L. 142 ...	The Workington Iron and Steel Co., Ld., M. L. No. 142.	208,436
Channagiri ...	Hoshalli near Joladhal	P. L 116 ...		
	Hoskere	,, 210 ...		29,905
Shimoga ...	Shankargudda	M. L. 141 ...	The Workington Iron and Steel Co., Ld., M. L. No. 141.	14,430
	Bikonhalli and Kunchanalli	P. L. 27 ...		
	Bhadigund	,, 265 and 290		3,297
	Balekatte near Shiddarhalli	,, 153 ...	Messrs. Jambon & Co., P. L. No. 153.	1,638
	Hill 1½ miles N.W. of Shiddarhalli	,, 102 and 372	Mr. S. N. Subba Rao, P. L. No. 372.	
	Mavinkere E. of Masarahalli	,, 215 ...		
Tirthahalli ..	Aranelli (Siddargudda and Chaudigudda slopes) ...	,, 86 ...		70
	Karkodlu 10 miles W.S.W. of Shankargudda ...	,, 118 ...		753
			Total ...	261,532
	KADUR DISTRICT.			
Tarikere ...	Shiddarhalli 8 miles N. of Tarikere	P. L. 96 and 136 ...		10,235
			Total ...	10,235

	CHITALDRUG DISTRICT.			
Davangere ...	1½ miles S.W. of Halekal	P. L. 100 ...		10,510
Holalkere ...	Davanhalli and Kandavadi ... } E. of Jajur Railway Station.	,, 312 ...		911
	Chikkandavadi ... } E. of Jajur Railway Station.	,, 60 ...		25
	Sadarhalli ... } E. of Jajur Railway Station.	,, 103 and 375		752
	Arasangatta ... } E. of Jajur Railway Station.	,, 59 ...		300
	Mahadevapur ... } E. of Jajur Railway Station.	,, 417 ...	Mr. V. Manickavelu Mudaliar, P. L. No. 417.	
	△ 2706 2 miles N.W. of Shivagange	,, 104 and 376		248
	Shivagange	,, 366 ...		10
Hosdurga ...	Karekalgudda, 6 miles N. W. of Madadkere ...	,, 43 and 411...	The Peninsular Minerals Co. of Mysore, Ld., P. L. No. 411.	22
	Kenkere, 3 miles N. W. of Madadkere	,, 43 and 412...	Do P. L. No. 412	
	Madadkere	,, 41 ...		
	Hills 3 miles S. of Chik Byalkere	,, 31 ...		11
			Total ...	12,789
	TUMKUR DISTRICT.			
Chiknayakanhalli...	Hills 1 mile S.W. of Janehar N.E. of Chiknayakanhalli	P. L. 53 ...		7,011
	Hills 2 miles N.E. of Honnebagi N.E. of Chiknayakanhalli	,, 51 ...		883
	Hill 1 mile S.W. of Narsihalli W.N.W. of Dodguni	,, 55 and 413...	The Peninsular Minerals Co. of Mysore, Ld., P. L. No. 413.	14,391
Tiptur ...	Karakurchi, W.N.W. of Dodguni	,, 55 and 414 ..	Do P. L. No. 414	
Gubbi ...	3 miles N.N.E. of Dodguni	,, 33 and 410...	Do P. L. No. 410	
			Total ...	22,285
			Grand Total to end of 1914 ...	306,841

Coming south again we find a deposit at Bikonhalli, 5 miles north of Shimoga, from which some 3,000 tons were obtained of cavernous and somewhat siliceous ore capping a small hill which is now exhausted.

It may be noted that the better class ores such as those at Shankargudda, Choradi, Kumsi and Bikonhalli lie on an inner chain not far from the boundary of the Shimoga gneissic granite, while the outer chain embracing Karkodlu, Tuppur and the Shikarpur group contains, as a rule, low grade deposits high in iron and usually particularly high in phosphorus.

The other deposits of this division lie to the east of the Shimoga granite in the Channagiri and Tarikere Taluks. Amongst these may be mentioned a number of small deposits to the south of Joladhal, of which that at Hoshalli was the most important but is now abandoned. Here the ore went down nearly vertically in a banded or impregnated zone some 6 feet or so in width. At a depth of 40 feet the band was rather split up and not sufficiently wide or solid to justify the cutting back of the narrow excavation or the adoption of underground mining.

The other places marked on the map are :—

Bhadigund, 7 miles south of Joladhal.

Shiddarhalli and Balekatte, 8 miles north of Tarikere.

Mavinkere, 4 miles east of Masarhalli Railway Station.

The various pits at Shiddarhalli yielded over 10,000 tons of 2nd grade ore in which the silica was rather high and a good deal of sorting was required. Much of the ore was float in lateritic soil and clay some of which was pisolitic. Beneath the float were some bouldery ore bands dipping about 30° to 40° to the north which were followed to a depth of about 30 feet but were not sufficiently large to justify the large amount of excavation necessary to carry down the open workings. The area contains a good deal of manganese most of which is 2nd or 3rd grade ore and is contained in talus or float deposits; it is possible that deeper deposits of good ore exist which are covered by the heavy overburden of soil and talus and the search for which would be expensive and largely fortuitous.

In the Chitaldrug Division manganese has been found at many points along the western sides of the Chitaldrug schist belt, but the ores are mostly poor and highly ferruginous.

A considerable group of deposits occur to the east of Jajur consisting largely of low grade talus material. On the ridges a few miles to the south there are indications of vertical bands of psilomelane in the schists, but not sufficiently strong to warrant either open work or underground mining. It is however an area which might well receive some further attention. Some ore has been excavated at Kareckalgudda and Kenkere, to the north-west of Madadkere, and recent work has shown that some fair quantity of fairly good ore may be obtainable with careful work and close attention to sorting. Much of the ore is mixed with limonite.

Other small deposits have been found at Chik Byalkere and to the east of Chiknayakanhalli.

A small quantity of ore was obtained at Narsihalli, Karakurchi and Dodguni and recent prospecting work suggests that considerable quantities still await development, some of which will be of fairly good grade, and work is now being proceeded with by the Peninsular Minerals Company.

The ores of this area are associated with iron ores and large quantities of low grade ferruginous ores appear to exist and it is possible that deeper prospecting will disclose further quantities of higher grade ore. Most of the high grade ore at present developed in said to be pyrolusite.

Output.

The following table gives the total quantity of ore exported from the various Districts from 1906 to the end of 1914.

TABLE 9—*Quantity of ore exported from 1906-14.*

Year	Export Tons					Royalty
	Shimoga	Chitaldrug	Tumkur	Kadur	Total	
						Rs.
1906 ...	36,534	11	4,117	...	40,662	15,743
1907 ..	53,241	920	10,866	4,698	69,725	26,550
1908 ...	47,038	1,212	4,172	2,148	54,570	20,464
1909 ...	16,135	9,607	...	3,389	29,131	8,784
1910 ...	28,349	1,029	...	...	29,378	18,052
1911 ...	13,081	...	1,862	...	14,943	5,604
1912 ...	24,035	...	702	...	24,737	10,286
1913 ...	23,742	10	566	...	24,318	9,851
1914 ...	19,377	...	...	...	19,377	4,817
Total ...	261,532	12,789	22,285	10,235	306,841	1,20,151

Geological occurrence.

We cannot devote much space to this intricate and often obscure problem. Those who desire further information may be referred to Dr. Fermor's valuable Memoir on the "Manganese Ore Deposits of India" (1) and to the summary of his views in the "Quinquennial Review of the Mineral Production of India"(2).

In Mysore the deposits appear to be confined to the chloritic series of the Dharwar schists and to have resulted from the alteration of these schists to a comparatively small depth from surface. The manganese probably occurred originally in certain of those schists in minute quantities in the form of manganese, bearing silicates. The various silicates of the schists were subsequently broken up by the action of circulating waters and solutions giving rise to solutions containing manganese, iron, etc., from which the oxides of manganese and iron were deposited in segregated patches,

(1) Memoirs of the Geological Survey of India, Vol. XXXVII.
(2) Records of the Geological Survey of India, Vol. XLVI.

lenses, bands or veins in sufficiently concentrated masses to form ores. In these segregated patches the original schist has been removed and replaced by the manganese and iron minerals to a variable extent and we get various earthy ores, wads, etc., hardening up in places by addition of further mineral matter to rich ores. Local conditions, of which we have no knowledge, have determined that in places the manganese is deposited by itself forming manganese ore and in other places the iron segregates to itself forming iron ore, while between these types there has been a very extensive formation of mixed ores in which the relative proportions of manganese and iron vary widely. It is not possible to say how deep the original solvent action may have extended, but it is probable that the concentration and formation of these ore masses is confined to comparatively shallow depths probably within 100 to 200 feet from surface and it is doubtful if any of the Mysore deposits will exceed 100 feet or so in depth. At Kumsi ore is now being worked at over 80 feet below surface and there are signs that the ore bodies are changing and petering out.

The ores are frequently associated with banded ferruginous quartzites and it has been suggested that the alteration of these rocks may have given rise to the ores. It is true that these rocks are sometimes veined and impregnated with manganese and that much altered remnants of them are found in the banded ochres and altered schists in which the manganese ores occur. As one of the members of the schist series they may have contributed their quota to the manganiferous solutions, but the proportion was probably not large compared with that from the large masses of altered schist with which they are associated.

The larger deposits in Mysore occur on ridges or comparatively high ground and the presence of the highly resisting quartzites has in many cases determined these elevations and preserved the ores and the soft ochres from denudation and the relationship of the quartzites to the ores may be protective rather than genetic.

A number of the smaller deposits occur on the slopes and on the lower ground and these appear to be largely of the nature of detrital or talus deposits derived from the breaking down of ores once situated at a higher level. Ores have been found *in situ* beneath some of these talus deposits, but they have not been proved to be extensive and may represent the remnants or roots of larger lenses or bands the greater portions of which have been worn away.

Laterite.

Lateritic material is frequently associated with the ores. In some cases, as at Shankargudda, this appears to be genuine laterite formed *in situ* on the surface of the altered schists. On parts of the ridge thin ore bands alternate with ochre and altered schist and the laterite has eaten its way down between the ore bands. Fragments and lumps of ore remain in the laterite and while these have been to some extent dissolved it is probable that some of them have, at some period, formed centres or nuclei for the segregative deposition of further quantities of manganese. The breaking up and denudation of these lateritic masses (or *lateritoid* as Fermor calls them) and of exposed ochres and ore bands have given rise to numerous talus deposits on the slopes or lower ground in which large lumps and nodules of ore are irregularly distributed in ferruginous clay and gravel which is often reconsolidated into lateritic material of secondary origin. These talus deposits and the soil associated with them are often very full of gravel consisting of rounded and concentric pisolites of limonite with variable amounts of manganese. Some of these are derived from the weathering of pisolitic ore and some correspond to the ordinary lateritic gravel which is so commonly found as detrital material derived from typical laterite. In the latter case the pisolites do not exist in the laterite itself, but are produced by the breaking up and rounding of small veins or segregations of limonite with subsequent coats of limonitic ore deposited round them.

At Holmes' pit, Kumsi, there are large masses of low grade pisolitic manganese ore, fractured into lumps, between which the ore has altered to highly ferruginous material which is becoming cavernous and lateritic in appearance.

Grade and Composition of Ores.

In Table 11 is given a selected list of analyses which have been kindly furnished by the licensees of the various blocks. The list is less complete than could be desired, as in many cases shipments have been made of mixed ores from several blocks and complete analyses are not available for many of the separate deposits. When considered in bulk the ores are considerably lower in manganese than those from the Central Provinces. The greater portion consists of psilomelane the lower grades of which are frequently pisolitic. There is a fair amount of wad passing into psilomelane, some pyrolusite much of which is cavernous, rather friable and powdery, and some manganite and other undetermined varieties.

The grading of the ore is an arbitrary matter and the following table shows the approximate limits adopted in the Central Provinces and in Mysore.

TABLE 10—*Grading of Manganese Ores.*

	Central Provinces	Mysore
1st grade ...	50 per cent Mn.	47-52 per cent Mn.
2nd ,, ...	48-50 ,, ...	42-47 ,,
3rd ,, ...	45-48 ,, ...	38-42 ,,

According to this the Mysore ores are relatively about one grade lower than those of the Central Provinces in manganese contents and many of the former would be classed by Fermor as Ferruginous Manganese Ore or Manganiferous Iron Ore.

On the other hand, the low silica and phosphorus in the Mysore ores and their good smelting qualities raise their value and justify the better class ore being regarded as 1st grade even though it may average only about 48 per cent Mn.

From Table 11 it will be seen that in addition to much local variation there are some general variations in the ores from different localities. The ores from round about Joladhal in the Channagiri Taluk and Shiddarhalli in the adjoining Tarikere Taluk are remarkably low in phosphorus often under 0·01 per cent. Much of this ore is low in manganese and high in iron and some fairly high in Silica. At Holmes' pit, Kumsi Taluk, the phosphorus is low, averaging about 0·04 per cent, and is still lower in the Python deposits close by.

At Shankargudda both phosphorus and iron are higher than at Kumsi and average about 0·07 per cent and 10 to 12 per cent respectively. The ores at Karekalgudda and Kenkere in the Hosdurga Taluk appear to be somewhat of the same class. At Karkodlu and other small deposits in the Tirthahalli Taluk and in the small deposits around Itigehalli, Hosur and Ballur in the Shikarpur Taluk the phosphorus is much higher than elsewhere and runs from about 0·1 to 0·25 per cent and the iron and silica is also high.

TABLE 11—*Analyses of Mysore Manganese Ore.*

No.	Place	License No.	Mn	Fe	P	SiO_2	Al_2O_3	Description
				SHIMOGA DISTRICT.				
1	Holme's Pit, Kumsi ...	M. L. 142 ...	25·87	27·24	0·031	2·81	6·5 approx.	Low grade; pisolitic; becoming lateritic.
2	Do do ...	,, ...	35·42	14·31	0·049	5·50		Pisolitic float ore in lateritic debris N.E. of pit.
3	Do do ...	,, ..	36·40	15·8	0·037	2·5	6·98 ...	Average of 3rd grade, chiefly psilomelane.
4	Do do ...	,, ...	40·20	6·0	0·018	4·28	17·05 ...	Aluminous ore N.E. corner of pit.
5	Do do ...	,, ...	54·5	5·93	0·042	1·5	Probably under 2 per cent.	Psilomelane, main run of boulders.
6	Do do ...	,, ...	42·4	10·8	0·052	2·2		Black wadlike ore hardening into psilomelane.
7	Do do ...	,, ...	53·0	5·5	0·045	1·02		Crystalline pyrolusite with wad.
8	Do do ..	,, ...	48·0	7·5	0·04	1·5		General average of 1st grade ore.
9	Python No. 1, Kumsi...	,, ...	33·7	15·2	0·02	5·5	5·5 ...	Float ore in lateritic soil.
10	Do do ...	,, ...	37·9	11·8	0·02	5·5	5·5 ..	Ore immediately under float.
11	Do do ...	,, ...	42·6	9·0	0·027	6·01	8·85 ..	Main floor, chiefly psilomelane.
12	Do No. 2 do ...	,, ...	36·8	18·5	...	...		Pisolitic float.
13	Do do ...	,, ...	46·0	9·8	0·033	3·7		Top 6 feet below float.
14	Do do ...	,, ...	50·5	...	...	...		Silvery psilomelane.
15	Ridge deposit, Shankargudda.	,, 141 ...	44·8	13·0	0·058	2·0		Psilomelane. To depth of 5 feet in lateritoid.
16	Do do ...	,, ...	46·81	10·0	0.034	2·0		Banded ores underlying No. 15, from 5 to 16 feet.
17	Knoll deposit ...	,, ...	51·10	5·10	0·047	1·35		Average. *
18	Original workings ...	,, ...	32·34	22·93	0·092	3·89		Pisolitic; surface ores.
19	Do do ...	,, ...	40·04	15·37	0·127	2·96		Pisolitic; various stacks.
20	Do do ...	,, ...	43·50	13·0	0·063	2·0		Average 2nd grade. Psilomelane underlying pisolitic.
21	Do do ...	,, ...	49·28	10·70	0·081	0·89		Sorted ore.
22	Do do ...	,, ...	51·43	8·90	0·105	0·70		Do
23	Do do ...	,, ...	47·5	12·10	0·074	1·08		Average of 1st grade.

TABLE 11—*Analyses of Mysore Manganese Ore*—concld.

No.	Place	License No.	Mn	Fe	P	Insoluble residue	Al_2O_3	Description
				SHIMOGA DISTRICT.				
24	Karkodlu; Tirthahalli	P. L. 118 ...	32·21	23·92	0·155	7·05		Talus deposits N.E. of hill.
25	Itegehalli; Shikarpur...	,, 93 ...	43·16	13·54	0·256	6·0		Very small quantity.
26	Ballur; do .	,, 99 ...	32·52	12·38	0·120	28·70		Lateritoid ore; dressing makes little improvement.
27	Buda matti peak; Joldhal.	P. L. 116 ...	49·56	7·29	0·031	1·2		Sorted ore; chipped; chiefly pyrolusite, average about 46 per cent.
28	Buda matti east; Hoshalli.	,, ...	39·62	12·08	0·009	4·4		Talus deposit of limonitic psilomelane.
29	Hoshalli-Joldhal ...	,, ...	46·0	...	...	...		Average of sorted ore. Largely pyrolusite and manganite. Some of the ore is said to have given over 50 per cent.
30	Treasury Hill; 2 miles S.S.E. of Hoshalli.	,, ...	23·4	28·46	0·001	6·55		Banded psilomelane and limonite.
				KADUR DISTRICT.				
31	Shiddarhalli; Tarikere	P. L's. Nos. 96 and 136.	44·7	8·50	0·002	8·0		Average of several pits. Some ore running 48·49 per cent Mn. and 2·5 per cent insoluble residue also obtained.
				CHITALDRUG DISTRICT.				
32	Sadarhalli, Chikjajur ..	P. L's. Nos 103, 312 and 375.	37·7	21·3	0·018	2·1		Sorted ore at station.
	Do do ...	,, ...	19·0 to 26·0	38·0 to 27·0	...	...		Samples from various pits.
33	Karekalgudda ...	P. L's. Nos. 43 and 141.	47·60	10·0	0·065	1·63		The average ore shipped ran about 45·5 per cent. There is a lot of low grade ore under 40 per cent.
	Do ...	,, ...	41·20	17·0	0·063	2·13		
34	Kenkere ...	P. L's. Nos. 43 and 412.	50·72	7·35	0·06	1·85		

The workings at Kumsi and Shankargudda have shown that a notable improvement in grade occurs at several points at a small depth below surface below the 3rd grade ores, many of which are pisolitic. Analyses 9 to 11, 12 to 14, 15 and 16, 19 and 20 show this improvement and we have been informed recently that the ore in some of the laterite which averaged about 30 per cent manganese has now been succeeded at a depth of 25 or more feet by ore running 45 to 46 per cent manganese. It is interesting to note also that much of the float ore in lateritic soil and gravel is of comparatively low grade and that beneath it ores of better grade have been found. This is particularly the case when the float is composed of pisolitic ore and it seems to be the rule that the pisolitic ores when *in situ* are restricted to the more superficial portions of the deposits. The origin and relationships of these pisolitic ores are still very obscure, but from the point of view of practical prospecting it is important to find that low grade float and surface ores are sometimes underlain by higher grade ores and that surface trenches to a depth of 10 feet or more may reveal only poor ores and cause abandonment of work leaving better ores below undetected and untouched.

Improvement in Depth.

The cost of winning the ore and taking it to a market is a very variable one and depends on the character of the deposit, distance from a railway and freight charges. The following figures for the Central Provinces are given by Fermor. (1)

Cost of Ore.

Contractors are paid from Rs. 30 to Rs. 60 per 1,000 cubic feet of stacked clean ore. At 16½ cubic feet to the ton this comes to eight annas to one rupee per ton of ore. An additional payment of Rs. 5 to Rs. 6 per 1,000 cubic feet of excavation is made to cover the cost of removing waste material the proportion of which to ore varies very considerably. This charge may amount to from one anna to one

(1) Memoirs of the Geological Survey of India, Vol. XXXVII, Chapter XXIII.

rupee per ton of ore making the contract charge 9 annas to Rs. 2 per ton. Dead work, plant, tools and administration may vary from 8 annas to Rs. 1-8-0. Transport to railway by cart costs $2\frac{1}{2}$ to $2\frac{3}{4}$ annas per ton mile and loading into railway waggons 1 to $1\frac{1}{2}$ annas. Various wharf dues at Bombay vary from $11\frac{1}{2}$ annas to Rs. 1-8-0 and at Marmugoa Rs. 1-3-0.

Ocean freights including insurance have varied from Rs. 12 to 15 and charges at destination run from 14 annas to Rs. 1-11-0.

These charges are assembled in Table 12 to give an idea of average cost of ore c.i.f., English and Continental ports.

In Mysore we have comparatively few figures relating to large consignments of ore. Those despatched by the Workington Iron and Steel Company go mainly to their own works in England while much of the ore obtained by other licensees has been sold at contract prices on the railway or at Marmugoa.

At Kumsi and Shankargudda in the Shimoga District, where the most extensive workings are situated, the average contract rate is about Rs. 2-2-0 per 100 cubic feet of excavation excluding preparation of site, removal of surface soil, etc. The cost per ton depends on the relative amount of ore and waste or *mutti*. Except in the case of talus deposits the ore bands and lenses are usually steeply inclined and in order that a fair proportion of ore may be obtained it is necessary that the ore bodies should be wide or that several bands should be sufficiently adjacent to be included in one pit. At Kumsi the heavier ore bands yield about 3 tons per 100 cubic feet and the average is about $1\frac{1}{2}$ tons of marketable ore, *i.e.*, excluding large quantities of low grade ferruginous ore. At Shankargudda the quantities are rather higher, say $3\frac{1}{2}$ and 2 tons, respectively. The average contract rate at Kumsi is therefore about Rs. 1-6-0 per ton and includes mining, sorting and removal of waste.

Supervision, tools, plant and loading costs Re. 1 to Rs. 1-2-0.

Transport on tramway (27 miles) to Shimoga including maintenance, running costs, loading and unloading, Rs. 2-3-0.

Administration, office, royalty, etc., Rs. 1-6-0.

Rail to Marmugoa and port charges, Rs. 6-8-0.

Sea freight and insurance, Rs. 12-12-0.

The figures for the Central Provinces and Mysore may be put in the following tabular form :—

TABLE 12—*Cost of Manganese Ore per ton.*

	Central Provinces *via* Bombay			Shimoga (Mysore) *via* Marmugoa	
	Limits	Average			
	Rs. a. Rs. a.	Rs.	a.	Rs.	a.
Mining work				1	6
Supervision, tools, etc.	1 0 to 4 0	2	12	1	1
General administration				1	6
Transport to railway	Nil to 5 0	1	8	2	3
Railway freight	7 6 to 8 15	8	0	6	8
Handling at port	0 10½ to 1 8	1	4		
Agents' commission	Nil to 0 4	0	2	0	2
Cost f.o.b. at port	9 0½ to 19 11	13	10	12	10
Sea freight and insurance	9 0 to 15 0	12	0	12	12
Destination charges	0 14 to 2 0	1	4	1	4
Cost c.i.f. at destination	21 8 to 36 11	26	14	26	10

The ore from Kumsi therefore costs about Rs. 6 per ton at Shimoga excluding interest on the cost of the tramway which may raise it to Rs. 7 per ton. Such charges as interest, administration and tramming depend largely on quantity and due allowance must be made for this. In cases where bullock carts have to be used the usual rate is four annas per ton mile and the cost of ore from such properties as Shiddarhalli and Hoshalli, situated up to 15 miles from the railway at Tarikere or Benkipur, used to come to some Rs. 8 or 9 at the railway station. We may take it that ore from the various manganiferous areas in Mysore will usually cost between 12 and 15 rupees per ton f.o.b. Marmugoa and the question whether it can be sold at a profit or not depends mainly on the market rate and on sea freights.

Value of Ore.

Manganese ores are sold on a basis of so many pence or annas *per unit* of manganese contained in the ore—the number of units being equal to the percentage of manganese.

The sale value of a ton of manganese ore containing 48 per cent of Mn. when the market rate is 10 annas per unit is $48 \times 10 = 480$ annas, or Rs. 30. The market rate varies for 1st, 2nd and 3rd grade ores and there are certain restrictions if the silica exceeds 10 per cent or the phosphorus 0·1 per cent.

The market rates have varied very considerably during the past few years.

In 1906-07 the rate for 1st grade ore rose to between 15 and 16 annas per unit and there was a considerable boom in mining and prospecting for manganese.

In 1908-09 the rate fell to about 9 annas and work became much restricted as many of the ores could not be exported at a profit.

In 1913 it rose to between 11 and 12 annas but these better prices were discounted by high shipping freights. There was a fall again in 1914, and since then war freights have rendered shipments almost impossible.

As already pointed out much of the Mysore ore is 2nd or 3rd grade and the rates for these run about one anna per unit less for each successive grade. If 1st grade is 9 annas, 2nd grade will be about 8 and 3rd grade about 7 annas per unit. Assuming according to Table 12 that the Mysore ore can be delivered in England or Europe at a cost of Rs. 27 per ton or 432 annas—

a 48 per cent ore will cost $\frac{432}{48} = 9$ annas per unit and cannot be sold at a profit unless the market rate exceeds

9 annas. For lower grade ores the position is still worse and it is obvious that the majority of the Mysore ores require either high rates or low working expenses and freights to make them profitable. In some cases a rate of 2½ to 5 annas per unit may be obtained for the iron in the ore and if silica and phosphorus are low it may sometimes be possible to export ores containing 40 per cent or less of manganese under favourable conditions.

UTILIZATION OF MANGANESE ORE.

Manganese ore is put to a large variety of uses of which the preparation of various alloys of iron and manganese known as spiegel-eisen and ferro-manganese is far the most important and takes some 80 to 90 per cent of the whole output of the world. Manganese is also added to steel up to a proportion of 20 to 30 per cent and yields a material combining great toughness and hardness which is used for special purposes such as tramway points and crossings, rock-breakers, rolls, gun shields, etc. Various bronzes and other alloys are made with copper, aluminium, zinc, etc.

As an oxidiser manganese is used for the preparation of chlorine and bleaching powder, decolouring glass and manufacture of permanganates. It is used as a colouring material for calico, glass, pottery and paints and for various minor chemical and manufacturing purposes.

Spiegel-eisen and Ferro-Manganese.

Alloys of iron and manganese containing from 12 to 30 per cent manganese are usually called spiegel-eisen and those from 30 per cent upwards are called ferro-manganese. The most usual alloys are 12 and 20 per cent spiegel and 80 per cent ferro and these are made by smelting manganese ores with coke in blast furnaces, in much the same way as pig iron is smelted from iron ore, only that the output of the furnaces is much less and the consumption of fuel much greater than in the manufacture of iron. Spiegel contains 4 to 5 per cent of carbon and ferro 6 to 7 per cent of carbon and they are added to molten steel, either in the furnace or in the ladle, in order to recarburize the steel to the extent required by the manufacturer. Spiegel is used chiefly for steel made by the Bessemer process and ferro in open hearth steels.

In addition to the recarburizing action the manganese purifies the steel by removal of oxygen and most of the manganese is converted to oxide and passes into the slag. It is usual to add sufficient alloy to leave a small excess of manganese in the finished steel to improve the rolling. On the average a total of about 3 per cent of manganese is required per ton of steel made and this accounts for the greater portion of the total production of manganese ore.

Manufacture in India.

With the exception of a few thousand tons of ore used in the iron and steel furnaces in India as a desulphuriser, practically the whole of the Indian output is sent to Europe where the greater part is converted to spiegel and ferro. The market value of the spiegel and ferro is probably from 3 to 5 times the value in India of the ore from which it is produced. The latter value has averaged over Rs. 120 lakhs annually during the past 5 years and the difference between this and the value of the manufactured article is represented as a very serious economic loss to India which could be reduced by manufacture in India on a large scale. Fermor has discussed the problem of manufacturing ferro at Sini on the Bengal-Nagpur Railway from the 52 per cent ores of the Central Provinces on the following basis:—

Materials required.		Rs.	a.	p.
1·9 tons ore at Rs. 22-8-0 per ton	...	42	12	0
2·5 tons coke at Rs. 16 per ton	...	40	0	0
1·0 ton limestone ...	...	5	0	0
Total materials	..	87	12	0

If we add Rs. 12-4-0 for fixed charges, labour, etc., the cost of manufacture comes to Rs. 100 per ton which is about equal to the cost of manufacture in England with imported ore. To send the ferro to markets in England and Europe would probably cost Rs. 30 for rail and sea freights, dues, etc., and the cost of packing in barrels would probably be considerable and the prospects of selling at a profit in those markets does not seem very promising. In America the price is said to have averaged Rs. 191-12-0 from 1901-1907 and it would seem that even after allowing for packing, transport charges, etc., it should be possible to deliver Indian ferro at Pittsburg for less than that price, but the same argument would apply to ferro manufactured in England and the shipping expenses would probably be less from England than from India. Since the period quoted the average import value into America has been considerably lower—about Rs. 150 in 1913. It is possible that a material reduction might be made in the cost of ore and coke especially in the case of a company using its own ore and fuel and the problem is worth further attention in specific cases.

There is very little demand for ferro in India itself, probably not more than a couple of thousand tons a year, but it will probably increase somewhat in the near future. No doubt this could be supplied from India at a considerably lower figure than it can be imported for. The imported ferro costs some £10 to 11 per ton f.o.b. English ports to which must be added some Rs. 40 for transport, dues, import tax, etc., making the cost in India about Rs. 200 per ton.

The most serious point for consideration is the high percentage of phosphorus in the Indian ore and coke. The ore from the Central Provinces contains about 0·09 per cent P and Indian coke, such as that used at Sakchi, contains some 14·7 per cent of ash carrying, 0·93 per cent P. Coke with lower phosphorus may be available, but if we take the above figures and assume that all the phosphorus goes into the ferro we get the following figures :—

1·9 tons ore (0·09 per cent P)	=0·0017	tons P
2·5 tons coke (0·136 per cent P)	=0·0034	,,
Total ...	0·0051	

or 0·51 per cent P in the finished ferro.

It has been stated that it is not desirable that the P should exceed 0·22 per cent in an 80 per cent ferro and though doubtless this amount is often exceeded the fact of a very large increase as indicated above would diminish the value of the local ferro or cause a more expensive ferro to be preferred.

Manufacture in Mysore.

It has been necessary to consider the above few facts in connection with our gigantic neighbour before discussing possibilities in Mysore. If we had to enter into competition with a product made in British India on a large scale the position would be hopeless just as it is hopeless for Mysore to make ordinary pig iron in competition with Sakchi. Just as in the case of iron and steel the only chance for Mysore lies in the production of a high class product and we have two factors which favour this, *viz*:—an ore low in phosphorus (0·05 per cent or even less) and charcoal fuel which is practically free from phosphorus—with the result that we could produce a ferro (77 per cent) with not more than 0·1 per cent P.

Charcoal Smelting.

We will assume that charcoal can be obtained although, as pointed out already, the supplies are small and may all be required for iron smelting. We will also assume that ferro and spiegel can be smelted in a charcoal furnace though we have no definite information that this has been done.

A good deal will depend on the cost of ore, but if the smelting is done by a company like the Workington Company using its own ore the cost may be taken at Rs. 7 per ton at Shimoga for higher grade and Rs. 5 for lower grade.

The following approximate estimates contemplate the production of 5,000 to 8,000 tons of 77 per cent or 60 per cent ferro or 10,000 tons of 30 per cent spiegel.

For 77 per cent ferro we assume ore containg 48 per cent Mn. and 8 per cent Fe.

For 60 per cent ferro we assume ore containing 35 per cent Mn. and 17 per cent Fe.

For 30 per cent spiegel we assume ore containing 30 per cent Mn. and 24 per cent Fe.

TABLE 13—*Cost per ton of Ferro and Spiegel in Mysore.*

	77 per cent Ferro		60 per cent Ferro		30 per cent Spiegel	
		Rs.		Rs.		Rs.
Manganese ore ...	2 tons at Rs. 7.	14	2 tons at Rs. 5.	10	1¼ tons at Rs. 5.	6¼
Iron ore ...	...	...	...	...	12 cwt. at Rs. 3.	1⅘
Charcoal ...	2¼ tons at Rs. 25.	57	2 tons at Rs. 25.	50	1½ tons at Rs. 25.	37½
Limestone ...	8 cwt. at Rs. 5.	2	8 cwt. at Rs. 5.	2	8 cwt. at Rs. 5.	2
Labour ...		4		4		
Repairs and relining.		5		4		
Supplies and sundries.		3		3	}	17½
Management and supervision.		5		4		
Interest and depreciation.		6		5		
Total ...		96		82		65

The figures for management, interest, etc., are somewhat problematical and depend on quantity and on combination of the work with other work, but the variations which might arise are not likely to total more than a few rupees per ton.

The production of a 77 per cent ferro might not be advisable as we have not a very large supply of the higher grade ores and to use them locally might very seriously interfere with the export of much larger quantities of lower grade ores which the former help to bring up to a marketable standard. On the other hand the use of ores containing 35 per cent Mn. or less for the production of lower grade ferro and spiegel would be an unmixed blessing as these ores are practically useless for export and are often a waste product of the mining work.

Assuming that the smelting work is technically possible it remains to enquire whether we can sell these products at a profit. It is very doubtful if the products could sell in

European markets unless specially high prices were offered on account of the low phosphorus (0·1 per cent or less). To the cost price at Shimoga must be added :—

	Rs.
Railway charges to Marmugoa ...	7
Freight and insurance	20
Charges at destination	3
Packing (cost not known)	5
	35

For the 77 per cent and 60 per cent ferros this Rs. 35 will have to be added making the c.i.f. costs in England Rs. 131 and 117, respectively. In the case of the spiegel if packing is unnecessary we may reduce the freight by Rs. 5 and packing by Rs. 5 making the addition for transport, etc., Rs. 25 and the c.i.f. cost of the spiegel Rs. 90. In England the sale price of 80 per cent ferro is about £9 or Rs. 135 per ton and that of 30 to 35 per cent spiegel about £5 to 6, or Rs. 75 to 90, per ton and it would therefore seem that the Mysore products could not be put on the market at less than the general selling prices so that no profit would remain unless special prices were obtainable.

There is practically no demand for 60 per cent ferro. We might sell a couple of thousand tons of 77 per cent in India in substitution of the 80 per cent now imported. The latter, as shown above, costs about Rs. 200 at Sakchi.

Mysore 77 per cent would cost :—

	Rs.	
At Shimoga	96	per ton.
Transport to Sakchi ...	25	
Total ...	121	

and this should leave a good profit even if costs went up owing to smaller output.

It would be more advantageous from many points of view if the steel works would use 60 per cent ferro and we do not think there is any real difficulty in doing so in open hearth furnaces.

The 60 per cent ferro would cost :—

		Rs.
At Shimoga	...	... 82
Transport to Sakchi		... 25
	Total	... 107

It would be necessary to use $1\frac{1}{3}$ tons of 60 per cent, costing Rs. 143, to replace 1 ton of 80 per cent, costing Rs. 200, which still leaves a good margin for profit.

In the case of places like China, Japan and Australia transport ought not to cost more than the figures given above for England and we should therefore be able to land the Mysore products there at about makers prices in England with the packing and transport charges from England in our favour in the shape of profit.

These various suggestions are, we think, worth the attention of practical men, but as the technical and commercial problems involved are intricate and rather obscure we do not feel justified in recommending definite action without further advice.

It must not be forgotten that the supply of charcoal is limited and that the whole of the reputed supply has been allotted to the iron smelting scheme already discussed. It would be safer and sounder to embark on the iron scheme than on ferro and the latter might come in as an adjunct if the opening up of the forests shows that sufficient charcoal can be made available.

In default of sufficient charcoal would it pay to use electricity? For several years the use of electricity has been suggested and considered.

Specially high grade ferro is made in electric furnaces in Europe for special purposes and fetches very high prices. Some of this contains 90 to 95 per cent Mn. and less than 2 per cent, or even 1 per cent of carbon and sells at prices up to £100 or more per ton. The demand is, however, very small and is probably insufficient to keep a single furnace running for one tenth of its time.

Electric Smelting of Ferro-manganese.

The question we have to consider is whether we can produce a good or superior ordinary ferro at a price which will compete with charcoal smelting or at a price which will pay.

The following figures are based on such information as we possess, but the consumption of power and electrodes are doubtful points.

TABLE 14—*Cost of Electric Ferro (ordinary 77 per cent).*

	Rs.	a.	p.
2 tons ore at Rs. 7	14	0	0
7 cwts. charcoal at Rs. 25	8	12	0
7 cwts. limestone at Rs. 5	1	12	0
6,500 K.W. Hours at 0·2 as. per unit ...	81	4	0
Electrodes	6	0	0
Repairs and relining	5	0	0
Management, labour and sundries ...	9	0	0
Interest and depreciation	7	4	0
Total ...	133	0	0

Thus with electricity as low as 0·2 anna per unit the cost is Rs. 37 more than for charcoal smelting.

The quality might be superior and fetch a higher price than ordinary ferro, but even at the above cost we could place the product at Sakchi at Rs. 158 per ton as against Rs. 200 now paid. It looks as if such a process might have some chance of success if the power can be obtained at a simple meter rate of 0·2 anna per unit at Shimoga, but we are doubtful if this can be done.

It would be possible also to place an electrically made 60 per cent ferro at Sakchi for less than the equivalent now paid and this, as already pointed out, would be advantageous to Mysore.

Other Ferro Alloys.

In the event of the establishment of an electric steel refinery it would be possible, with the addition of suitable furnaces, to conduct large scale experiments in the production of various ferro alloys which might lead to commercial production on a small scale. Amongst these may be mentioned manganese-steel, ferro-silicon (Fe, Mn) silicon-spiegel (Fe, Mn, Si), ferro-chrome (Fe, Cr), ferro-titanium (Fe, Ti) and special titanium steels. The quantities which could be disposed of commercially would no doubt be small and the standing charges would be too high to render such work profitable if taken up as a separate enterprise, but it is quite within the bounds of possibility that some of these products could be made at a profit as accessories to the larger work contemplated for steel refining.

Chromium.

The various alloys and compounds of chromium used in the arts are obtained from the mineral *Chromite or Chrome Iron Ore.*

Chromite is a black to brownish non-magnetic mineral composed of the oxides of chromium and aluminium combined with oxides of iron and magnesium $[(Cr_2Al_2)O_3, (MgFe)O]$. The relative proportions of the various metals present vary considerably and the mineral is often associated with iron ores in which the amount of chromium may be only a few per cent.

High class chrome ore contains from 50 to 58 per cent of Cr_2O_3; the ore becomes less readily saleable as the proportion of chromium oxide decreases and there is little demand for ore containing less than 42 per cent with 5 per cent or more silica.

Distribution and Occurrence.

Chromite has been found during the course of survey work at many places in the Shimoga, Hassan and Mysore Districts. In most places it occurs as grains in altered amphibolites, pyroxenites and dunite but too sparingly to be of commercial value. It occurs more abundantly in the narrow Nuggihalli schist belt running S.S.E. from Arsikere for a distance of 20 miles. The rocks of the belt are largely hornblende and talcose schists with what are considered to be intrusive masses of amphibolite partly altered to potstones or talc schists.

The chromite occurs in the altered amphibolite in segregated patches associated sometimes with iron ore.

Low Grade Ores.

This chrome ore is of comparatively low grade (42 per cent Cr_2O_3) and consists of fine granular chromite in a talcose matrix and is of a dull greyish black colour. The ore appears to occur in large quantities, but so far none of it has found a market. It might be possible to concentrate it up to 48 or 50 per cent Cr_2O_3, but the want of water in the area would be a serious difficulty and the crude ore might have to be removed to some place where water is available. An attempt was made some years ago by the Mysore Chromium Company to start a concentration plant but after considerable expenditure on a water dam, plant, etc., the project was given up as not feasible. If the comparatively high prices which ruled in 1913-14 are maintained after the war a concentrating project may be worth further consideration, but it must be remembered that the market for chrome ore is a difficult one and some definite assurance would have to be obtained as to the saleability of the products.

High Grade Ores.

Further south, in the Mysore District between Mysore and Nanjangud, a number of patches of ultrabasic rock have been found which carry veins, lenses and segregated patches of chromite. Of these the most important is a narrow strip of altered dunite (Olivine rock) or peridotite, which is now a brownish coloured serpentine, running north and south for a couple of miles near Shinduvalli a few miles east of Kadkola. The serpentine lies in gneiss (which is considered to be intrusive) and contains grains of chromite. For a distance of a mile or so along a line near the middle of the strip a number of small, nearly vertical, veins of solid chromite have been found which vary from an inch to a foot or more in thickness. Towards the southern end one vein widened out to a lens 5 ft. wide and below this other separate lenses were found to a depth of 40 ft. in open workings. Underground work is now in progress and at a depth of 86 ft. a lens or vein over 170 ft. in length and up to 9 ft. in width has been opened up as well as two smaller veins to the west of it. The ore is massive and of good quality and the lens is broken into slab-like blocks by vertical and horizontal veins of magnesite which also traverse the serpentine.

*

In addition to the ore which has been mined from the Shinduvalli Block a large quantity of pebbles or lumps of chromite has been picked up on the surface of the ultrabasic patches.

Supplies in Other Countries.

In considering the sale or use of Mysore ores and particularly in regard to the problem of concentrating the low grade ores we must bear in mind that large quantities of good ore are obtainable from other countries with which Mysore cannot compare as regards either quantity or quality. In Baluchistan chromite has been discovered in serpentine associated with basic intrusives of cretaceous age. It is reported that considerable quantities of ore can be obtained much of which will average 54 to 57 per cent of Cr_2O_3 and most of which can be obtained by open work mining at moderate cost. Little precise information is, however, available. Up to the present the output has been small as it has to be carried 50 miles on camels to a railway; but that difficulty can be removed by extension of the line and in that case we might expect a large and regular supply from Baluchistan.

New Caledonia has been for many years the chief source of high grade ores averaging about 55 per cent Cr_2O_3. The ore occurs in alluvial or surface deposits close to the sea and the mining and f.o.b. costs are low. There is some reason to believe that these deposits are approaching exhaustion, but other less easily worked deposits are said to exist.

In Rhodesia vast areas of serpentinized rocks carry quantities of chromite most of which is of moderate grade, 47 per cent being usually quoted for shipment. The quantity of high grade ore is not very large though much larger than in Mysore and there is said to be a very large amount of medium to low grade ore. Here again large quantities can be cheaply mined in open workings though this is offset by the long railway lead to a port (Beira which is some 500 miles from the Salukwe area).

In comparison with these fields the high grade ores of

Mysore are of very limited extent and the problem of concentrating low grade ores will, we fear, be a doubtful proposition for many years in the face of the large supplies of easily mined high grade ore obtainable from elsewhere.

Composition of Ore.

The ore from Kadakola area is of good quality and runs from about 48 to 53 per cent Cr_2O_3. There is also some lower grade ore comparable to that from the Nuggihalli belt near Arsikere. The latter occurs usually in altered talcose amphibolite while the better class ore appears to be confined to the patches of serpentinised ultrabasic rock associated with magnesite.

Table 15 gives a number of representative analyses of the ores kindly supplied by licensees.

Cost and value of Ore.

Most of the ore has been obtained hitherto from surface collections, shallow pits and open workings down to a depth of 40 ft. The contract rates vary from Rs. 2 to 5 per ton of stacked ore. With the adoption of underground work the cost of the ore will increase and it is not possible to say what it will be in future. Much of the ore has been sold f.o.r. Kadakola at prices ranging from Rs. 8 to 15 per ton. Export has been very variable and home market values have appreciated considerably during the past few years. Table 16 shows the quantities despatched and sold to the end of 1914 and the average market rates in England for 50 per cent ore. The rate is generally subject to a variation of 2 shillings to 2*s*. 6*d*. per unit of Cr_2O_3 above or below 50 per cent. The prices are said to be controlled largely by an international combine and the market is far from being an open one.

Uses.

The greater part of the chrome ore production is used for the manufacture of chrome salts for dyeing and tanning. A considerable amount is used for the manufacture of ferro-chrome (alloy of iron and chromium) and the ore itself, either in lump form or crushed and pressed into bricks, is used as a refractory lining for furnaces.

TABLE 15—*Analyses of Mysore Chrome Ores dried at 100°C.*

No.	Cr_2O_3	FeO	Fe_2O_3	Al_2O_3	MgO	CaO	SiO_2	MnO	K_2O Na_2O	P_2O_5	SO_3	H_2O (combined)	Remarks
1	42·00	19·65	...	19·43	11·50	0·17	6·30	0·07	0·58	Trace	Nil	0·30	Low grade ore, Arsikere.
2	48·65	18·63	0·24	12·70	...	...	2·45	...	...	...	...	...	Bulk sample from Shinduvalli Block, Kadakola.
3	50·45	18·92	0·28	12·10	15·60	...	1·55	...	...	...	...	...	Sample ½ a mile north of No. 2. Nos. 2 and 3 contained adherent magnesite and could be further cleaned.
4	48·05	19·32	0·42	12·70	14·90	...	3·08	..	...	...	...	...	From veins and stacks East Gurur, Mysore District.
5	50·10	19·64	...	13·73	12·28	Trace	2·66	1·44	...	...	...	0·15 (loss)	Shipment, Kadakola ore.
6	50·78	16·97	0·50	14·55	14·30	0·75	1·00	0·55	...	0·03	...	0·62	200 ton shipment from Kadakola.
7	53·18	16·70	0·71	13·33	15·00	...	0·15	0·40	...	0·08	...	0·58	High grade sample, Kadakola.
8	51·70	17·34	0·49	13·80	14·60	...	1·90	...	...	...	...	...	Surface pebbles, Kadakola area.

There are no manufactures of chrome products in Mysore and it is difficult to say if there is any reasonable prospect of their being established. The absence of cheap supplies of alkali and sulphuric acid is a bar to the production of the salts which may or may not prove insuperable. The production of ferro-chrome might become possible as an accessory to electric steel refining as already pointed out. It is not easy to obtain any reliable or detailed information as to modern methods and costs of production. Chrome ore was, at one time, smelted with coke in small blast furnaces giving a ferro-chrome containing some 40 per cent of chromium and 10 to 12 per cent carbon. With special blast arrangements a 60 per cent ferro-chrome has been produced in the blast furnace. At the present time it is made entirely in electric furnaces of the Heroult or Girod type, and from carefully selected ore it is not a difficult matter to produce a 60 per cent ferro-chrome containing 6 to 8 per cent carbon which is worth about £20 to 25 per ton. For special work ferro-chrome containing up to 75 per cent chromium and 1 to 2 per cent carbon is now produced and is worth £60 to 70 per ton. We cannot however give details of the process. Practically pure chromium without carbon is produced by the thermite process of Goldschmidt by igniting a mixture of pure Cr_2O_3 and aluminium powder.

Although we cannot give exact details the following figures are probably not wide of the mark for the production of an ordinary 60 per cent ferro-chrome with 6 to 8 per cent carbon.

	Rs.
2 tons of selected ore delivered at furnace at Rs. 20	40
Electric energy 8,000 K.W. Hours at 0·2 anna per unit	100
Electrodes	10
Charcoal, labour, repairs and fixed charges ...	40
Total ...	190

The output could not be large as the demand for ferro-chrome is not great, though it will probably increase. It must be remembered also that the probable supply of high grade chrome ore in Mysore is not large and that unless it was found possible to concentrate the low grade ores and utilize the concentrates the total duration of the work would be relatively short and the amortization charges for the plant would be correspondingly high. For these reasons it would be necessary to combine the work with other electro-thermal work in order to keep supervision and other fixed charges down to a reasonable limit. Under such conditions it looks as though ferro-chrome could be produced at a cost of not more than Rs. 200 per ton and if the price is Rs. 300 or more there should be a margin of profit after paying for transport, agency, etc. The paramount influence of the cost of electric energy is shown above and any material increase in the rate would render the work prohibitive.

TABLE 16—*Production of Chrome Iron Ore in Mysore, during the years 1907-1914.*

Year	Quantity sold	Calculated value, c.i.f. English Ports		Royalty	Remarks
	Tons	Per ton 50 per cent basis	Total rupees		
		£. s. d.		Rs. a. p.	*Note.* The sale value in Europe as given, is estimated on the prevailing market value for chromite on the 50 per cent basis at each quarter of the year. The value of the ore at the mines averages about Rs. 12 per ton at present. *The ore is all from the Mysore District with the exception of a 10 ton sample from Arsikere (Hassan District).
1907 ...	862	3 5 0	42,023	323 4 0	
1908 ...	5,785	3 0 0	2,60,325	2,244 14 0	
1909 ...	3,533	2 3 0	1,13,940	1,859 6 0	
1910 ...	...	......	......	......	
1911 ...	830	2 7 6	29,569	311 4 0	
1912 ...	...	......	......	.....	
1913 ...	...	......	......	......	
1914 ...	165	2 18 6	7,239	140 0 0*	
Total ...	11,175	......	4,53,0[illegible]6	4,858 12 0	

Other Metalliferous Minerals.

Minerals containing copper, silver, lead, zinc and antimony have been found in various places, but the quantities so far discovered are commercially unimportant and may be referred to very briefly.

Copper. Copper-pyrites and cupriferous iron-pyrites occur sparingly in quartz veins and quartzites and in some of the chloritic schists and traps. In a few places these minerals, and possibly others, have been broken up by weathering and circulation of water to shallow depths and from the solutions so formed, copper salts have been deposited in cracks, fissures or porous decomposed rock in the zone of weathering which may extend to a depth of 50 to 100 feet from surface. These salts are the green carbonate *malachite*, the blue hydrous sulphate *chalcanthite*, commonly known as *Blue Vitriol* and sometimes various silicates of copper appear to be present. At Ingaladhal, 5 miles south-east of Chitaldrug, there are some old workings in the side and top of a small hill from which fibrous specimens of chalcanthite can still be obtained in the form of incrustations or small veins in a decomposed gritty schist which is probably an alteration of the gray trap of Chitaldrug. The mineral was doubtless more abundant in the patches excavated by the ancients but at present very little remains and prospecting work has failed to disclose anything of the nature of a body of copper ore. It is probable that the mineral which now occurs in the walls of the old tunnels is of comparatively recent formation and is formed by the oxidation and leaching of traces of copper sulphides from the mass of the rock.

Malachite has been found in tufts of slender acicular prisms in a thin vein in quartzite near Kaidall, 10 miles south of Davangere, Chitaldrug District. A surface sample gave 17·5 per cent copper, but some prospecting pits showed that the ore did not extend more than a few feet in any direction.

Copper carbonate occurs in the quartzite conglomerates to the north and north-east of Chikmagalur in the Kadur District, but a large number of samples showed that the copper never amounted to more than a heavy trace.

Traces of copper carbonate have been found at Kolur, 3½ miles east of Maddur, Bangalore District. In the Nanjangud Taluk, 1¼ miles S. S. E. of Biligere, pieces of green copper ore were found in the soil and some pits have been sunk to a depth of 40 feet under a prospecting license. The rock is a steeply dipping decomposed gneiss with an interbanded dolerite dyke of a few yards in width. The latter is considerably decomposed and shows strings and patches strongly impregnated with carbonate of copper. A piece of the gneiss (O/980) gave 0·25 per cent copper. A greenish grey sample (O/981) which may be a bleached portion of the dyke or some other trap gave 9 per cent Cu. and a dark brown ferruginous ore containing green carbonate and red oxide gave 24·32 per cent Cu. with 18 dwts. 15 grs. of silver. Sufficient work has not been done yet to enable one to judge whether any body of ore exists or which particular type of rock in this complex was the original home of the copper salts which now impregnate the various materials.

Silver.

There are traditional rumours of silver having been found in Mysore and names like Bellibetta (Silver Hill) are supposed to record such occurrences though no trace of silver ore is now to be found. Some small quantities of argentiferous galena, containing up to 130 ozs. of silver to the ton, have been found and are mentioned below under lead. It may not be generally known that the ore of the Kolar Gold Field contains silver which is recovered with the bar gold and afterwards separated during the final refining process. The bar gold contains from about 5½ per cent to 9½ per cent of silver, the average being about

7·85 per cent. An estimate based on the gold returns shows that up to the end of 1914 the Kolar Field has produced about 8,84,532 ozs. of fine silver valued at 18 lakhs of rupees. The annual production based on the figures of 1913 is now about 44,500 ozs. valued at Rs. 82,000.

Lead.

A small quantity of argentiferous galena (lead sulphide) was discovered by Mr. Sambasiva Iyer about a mile S. E. of the village of Kurubarmardikere in the Chitaldrug Taluk. The ore occurs in small stringers from $\frac{3}{4}$ to $1\frac{1}{2}$ inches thick in gritty calc-chlorite schists which are probably alterations of the gray trap. There are only a few short stringers and some pits failed to reveal any tendency to increase in size or number. The clean ore assayed 134·65 ozs. of silver and 72·29 per cent of lead, but the quantity is very limited and the expense of extraction would be too high to permit of profitable working.

In a few places a little galena has been noticed in quartz reefs, for instance:—just west of the ghat section on the road to Hiriyur close to Chitaldrug town, on the east slope of Nisanigudda, near Nakikere, Hiriyur Taluk; and to the north-west of Arothekoppal in the Tirumakudlu-Narsipur Taluk. It is also found sometimes in the gold quartz of the Kolar Field and in other places where gold mining has been tried, but in none of these cases has any noteworthy body of ore been disclosed.

Zinc.

The mineral Blende (sulphide of zinc) has been found in the Kolar Mines and in some old workings such as those at Bukkambudi in the Tarikere Taluk but only in comparatively small quantity. At Bukkambudi the talc-chlorite schists in the neighbourhood of the old working have mineralized streaks or bands containing finely divided sulphurets, such as galena, blende and iron pyrites, but the proportion of these is small and the mineralized zones of no great extent. In the old workings a few more highly mineralized bands occur in which the total concentrates would not average more than about one per cent of the rock. The low grade and the complex character of the concentrates preclude any reasonable prospects of working even if the mineralized zones were of large extent and this does not appear to be the case. It has been suggested that richer patches existed and were worked by the ancients for silver, lead and zinc, but it is more than doubtful if they could have treated such a complex mixture which would be a difficult proposition even under modern conditions. The rock is veined with quartz and carries a little gold and it is more probable that the old workings were excavated on some patches or lenses carrying fairly rich free gold.

Antimony.

The existence of small quantities of Antimony ore, in the Chitaldrug District, has been known for many years and in 1888 some samples of stibnite are said to have been collected by Mr. Mervyn Smith and sent to the Mysore Exhibition. In 1899 Mr. Sambasiva Iyer during the course of survey found some specimens of antimony ochre (cervantite) in the same locality but only in small quantities. More than one prospecting license has been taken out since and a large number of pits sunk in the search for both gold and antimony but without any satisfactory results. Loose blocks of a quartzose rock containing stibnite and cervantite were found, but neither the amount nor the grade of the ore was sufficient to justify further work.

Before the war the price of antimony ore in England varied from £6-10-0 to £10 per ton, but during 1915 the price rose very considerably to 10 shillings per unit or about £25 per ton for 50 per cent ore and a quotation for delivery in Bombay went as high even as Rs. 8 per unit. These prices were therefore three or four times the normal price and Mr. J. Burr of Bangalore took out a license in the hopes that under these favourable conditions the available ore might be mined and sold at a profit. Prospecting work has shown that the ore occurs in veins and patches in a quartzose rock in the chloritic schists. Veins of a couple of inches in thickness have been located with wider bulges or lenses up to a foot or so in thickness. The ore is mainly stibnite (sulphide of antimony) altering to cervantite (oxide of antimony). Much picking and dressing is required to obtain ore of moderately good grade and so far the proportion of dressed ore has not exceeded about 1 per cent of the rock excavated.

The following Table shows the analyses of dressed samples of the ore :—

TABLE 17—*Analyses of antimony ores.*

No.		1	2	3	4	5	6
SiO_2	...	41·81	42·30	...	53·62	41·60	
Sb_2S_3	...	...	53·10	...	...	1·57	
Sb_2O_4	...	...	...	...	43·60	48·06	
Sb (total)	...	38·86	(37·70)	48·00	(34·4)	(37·00)	40·00
S ...	...	13·61	...	...	0·60	...	
Fe_2O_3 and Al_2O_3	...	2·56	1·00	...	1·92	2·45	
SnO_2	...	...	nil	...	...	3·60	
PbO	...	trace	nil	...	trace	0·41	
As ...	...	nil	nil	...	nil	nil	
Zn ...	...	...	nil	...	...	nil	
CaO, MgO, etc.	...	...	3·60	...	...	2·28	

In these analyses of the dressed ore, which have been kindly furnished by the licensee, Nos. 1, 2 and 3 are sulphide ores and Nos. 4, 5 and 6 are oxide ores. Nos. 3 and 6 have evidently been dressed rather more carefully, but on an average the sulphide ore is not likely to exceed 38 per cent antimony and the oxide ore 35 per cent antimony in dressed bulk samples. If some of the dressed ore can be sold so as to cover expenses, it will be worth while doing some further work on the chance of striking some richer material, but it is evident that even at the high prices now ruling the proposition is hardly likely to pay unless a marked improvement takes place. If we take the high quotation of Rs. 8 per unit at Bombay for 38 per cent ore the ore would be worth Rs. 304 per ton and this has to cover the cost of bagging and transport amounting to at about Rs. 34 and leaving Rs. 270 to cover cost of mining, dressing and sundries. If, as is reported, it takes 100 tons of rock to yield 1 ton ore we have only Rs. 2-12-0 per ton to cover these charges and it is rather questionable if there would be any balance for profit. If then the question of making a profit is a doubtful one when the ore fetches Rs. 300 or so at Bombay, the proposition would certainly not be attractive in normal times when the ore would fetch only Rs. 100 or less and this accounts for the fact that it has been left alone for so many years. The grade of the ore body would have to improve considerably before work under normal conditions could be seriously entertained.

The high prices now ruling may make it possible to collect the float ore and to do certain amount of excavation, sorting and dressing and to recover most or all of the expenditure with the chance that the work so done may disclose some more valuable ore bodies.

II. Minerals used in Various Industries.

(a) Abrasive Materials.

The abrasive materials available in the State are the minerals corundum and garnet and certain varieties of rock used for the preparation of mill-stones, whetstones, etc.

CORUNDUM.

The mineral corundum consists of oxide of aluminium ($Al_2 O_3$). It occurs in hexagonal crystals usually in double-ended pyramids the faces of which are often curved and give the crystals the shape of an elongated barrel.

In colour it varies from ruby red through various shades of brown, blue, green and white and usually contains various impurities such as the oxides of iron and chromium and mica, pinite and other silicates. Crystals or grains are frequently surrounded with a micaceous shell or with pinite-like material or green to black spinel. When pure and clear the red varieties are known as rubies and the blue as sapphires. These clear gem varieties are practically unknown in Mysore.

Emery is a dark opaque corundum containing much oxide of iron. It is obtained chiefly from Greece and Turkey but does not occur in Mysore.

Distribution.

Corundum of various grades and colours is widely distributed in Mysore and the principal localities are shown on the enclosed map. They may be grouped as follows:—

In the Sringeri Jaghir small quantities of good ruby corundum occur. Occasional large crystals of brown corundum have been found further south in the ghat country.

A number of deposits are found to the west and south-west of Arsikere.

On the eastern side of the State there are several corundum bearing areas in the Pavagada Taluk.

A large and important series of deposits occur in the Maddagiri and Goribidnur Taluks and another group round about Mandya.

Several groups occur in the Hunsur and Heggaddevankote Taluks of the Mysore District.

Occurrence.

The mode of occurrence and mineral associations of the Indian corundums have been described by Holland in Part I of the Manual of the Geology of India. A description of a number of the Mysore types and localities will be found in a paper by B. Jayaram in Part II of Records, Volume XV., published by this Department.

Most of the corundum obtained in Mysore is in the form of loose grains and crystals picked up in the surface soil. These have been set free from the rocks in which they occurred originally by the decomposition of the rock masses under ordinary weathering influences and, along with some of the other harder and more resistant minerals, they are found in the residual mantle of soil. Considerable quantities of this loose corundum have doubtless been removed in past times. In more recent years the quantities obtained and exported are shown in Table 18 and in recent years the production has been between 2,000 and 4,000 cwts. a year. It is probable that the supply, at any rate of the better classes, is now less abundant or less easily obtainable than formerly.

In many places the mineral has now been found *in situ* in both decomposed and hard rock.

A comparatively small proportion of the output has been obtained by excavating the soft decomposed rock and pounding it with wooden mallets or tilt hammers. The harder corundum is then separated by sieving and picking, but the resulting product usually contains much adherent impurity which may amount to 30 or 40 per cent. Up to the present no attempt has been made to work the hard rock.

The corundum occurs in veins or bands of pegmatite, syenite or granite which traverse the older gneisses. In many cases it appears to be an original constituent of such veins, but it is noticeable that in the majority of cases the gneiss contains included bands and patches of basic Dharwar rocks, such as hornblende and mica schist, hornblende and pyroxene granulites, pyroxenite and amphibolite and that the corundum-bearing veins are frequently associated, or in contact, with such patches and often entirely enclosed within some of the larger ones. In some cases there is evidence of segregation or enrichment near the contacts which is suggestive of mutual reaction and sometimes the corundum is within the basic rock, but in many other cases the corundum has all the appearance of a primary constituent of the acid vein.

Value.

It is difficult to ascertain the value of the mineral with any degree of accuracy. Licenses for collection are granted over large areas, the usual area being a taluk. The licensee pays the villagers for amounts collected by them from time to time and a certain amount of sorting and selection is done before the material is despatched to Madras. The cost of collection has tended to rise recently owing to a general rise in wages and the lessened abundance of material; on the average the cost of collection is now probably some Rs. 60 to 80 per ton. The ruby varieties are the most valuable and from Rs. 300 to 500 per ton has sometimes been offered in Madras for good grades. The amount obtainable is however small. The better classes of pink, brown and grey corundum may be worth from 100 to 250 rupees in Madras and other varieties 90 to 100 rupees. There is a large quantity of rather dull white to greenish corundum which is of little or no value and is distinctly softer than the better classes. It is probably a mixture of hydrous and anhydrous oxides and considerable quantities have been found in corundum-bearing rocks near Arsikere in the Hassan District and near Sargur in the Mysore District.

The pink to amethyst coloured corundum which was extracted from veins of decomposed rock near Kamasandra in the Bowringpet Taluk is stated to have been worth 250 to 270 rupees at Madras and the product was far from clean mineral. Down to water level the cost of extraction was about Rs. 150 to 200 per ton.

Various samples which have been sent to England have been valued at from £8 to £30 per ton.

In Canada large quantities of corundum-bearing rock are mined, crushed and the clean mineral extracted. The annual production is about 2,000 tons and the average value £22 per ton. There the veins or bands, many of which consist of nepheline syenite, are of large dimensions and permit of cheap open quarrying on a large scale. As the output is considerable the mining and dressing charges are comparatively low and rock containing only from 5 to 10 per cent of corundum is treated. In recent years the average grade has approached 5 per cent.

Treatment.

For the preparation of clean corundum the rock or mineral is put through breakers and crushers and graded into various sizes by means of screens.

The coarser sizes are then treated in jigs and the finer materials on various types of shaking tables.

The middlings or mixed materials from the jigs are crushed finer and retreated with the recovery of further corundum. In some cases a final treatment with magnetic separators is necessary to remove heavy magnetic minerals which come through the process with the corundum.

The amount of machinery required is considerable and the question of mining and dressing costs is largely one of quantity.

It would no doubt be very desirable to crush and dress the Mysore corundum locally and to export clean and carefully graded products instead of raw unclean mineral, but the quantities produced at various centres are probably much too small to warrant the expense of the plant and supervision. Even the total output from the State is small for any modern treatment plant.

As most of the corundum has to pass through Bangalore on its way to Madras, it might be feasible to put up a single treatment plant at Bangalore and purchase the whole output of the State. A better market for the finished and graded product might be obtained and the development of the output would very likely be encouraged by a regular demand.

This applies to the output of loose corundum crystals, but the plant would afford opportunity for experimental testing of some of the corundum-bearing rocks of the State. If some of these proved promising, further prospecting would be encouraged and some sufficiently large deposit might be found to warrant the erection of a plant or partial plant at the mine for the rough treatment of the rock.

The prospects are very problematical and various samples have been obtained and sent to America for trial and opinion. It must be remembered also that artificial abrasives such as carborundum, alundum, etc., are yearly becoming more serious competitors, and it is probable that carborundum can be produced for £27 or less a ton and will be preferred to corundum for most purposes.

TABLE 18—*Production of corundum in Mysore and the royalty realized thereon during the years 1900 to 1914.*

Year	Quantity exported	Average value at the mine	Royalty
	Cwts.	Rs	Rs.
1900	1,602	4,806	238
1901	1,490	4,470	261
1902	171	513	67
1903	...	..	...
1904	...	...	...
1905	1,299	3,897	685
1906	2,064	8,256	1,088
1907	1,086	4,344	559
1908	124	496	65
1909	436	1,744	229
1910	2,152	8,608	1,134
1911	2,505	12,525	1,020
1912	2,926	11,630	1,522
1913	4,150	20,750	2,179
1914	1,604	8,020	845
Total ...	21,609	93,059	9,892

GARNET.

The garnets are a series of complex silicates containing two or more of the metals aluminium, iron, calcium, magnesium, manganese and chromium. They occur in rounded crystals and grains and are very variable in colour, the commonest colour being pink, red or brown.

Distribution.

In Mysore red to brown garnets occur in a variety of rocks in many places of which the following may be mentioned.

In the Shimoga District they occur plentifully in mica schists lying in the gneiss between Agumbe and Koppa.

In the Kadur District near Sampigekan and Durgadhalli in hornblende schist and gneiss.

In the Hassan District near Yennehole Ranganbetta (Hole-Narsipur); near Bherya (Yedatore) where dull coloured and flawed crystals up to 3 inches in diameter are found; in the Manjarabad Taluk along the Kemphole and Adhalla streams and at Balekal, Kagneri, Murkangudda and Maranhalli in some of which places very large quantities of loose garnets can be obtained which have been weathered out of the hornblendic schists and gneiss. Most of these are small and some are clear and transparent.

In the Bangalore District pink garnets occur in pegmatite near Salhunse and small clear crystals and pebbles at Maralwadi in the Kankanhalli Taluk.

In the Kolar District there is a good deal of garnet sand in the streams near the corundum pits near Kamsandra.

In the Heggaddevankote Taluk of the Mysore District garnets occur freely in Kyanite schist and gneiss and loose pieces and fragments about ¼ inch in diameter can be washed from the surface soil. In addition to the above the mineral often occurs as a minor constituent in a variety of rocks.

Uses.

The larger clear varieties are used as gem stones. The Mysore minerals are not sufficiently large for the purpose when clear and of good colour, or when large they are dull in colour or much flawed and it has not been found possible to find a market for the stones. In several of the States of Rajputana a purple coloured garnet, belonging to the variety Almandite (iron-alumina garnet), is worked as a gem stone. The average yearly production for India from 1909-1913 is reported to be 298 cwts. valued at £1792(¹). The average value in different localities varies from about Rs. 30 to Rs. 150 per cwt.

There is a limited demand for garnet as an abrasive material, mostly for use in the leather and wood trades. The chief market is in the United States where the total consumption is some 4,000 to 5,000 tons per annum almost the whole of which comes from the Adirondack region of New York. The average value of the cleaned and graded mineral is about Rs. 90 per ton and about Rs. 105 for the best grade of crystal. The Adirondack mineral is said to be of the Almandite variety and to be somewhat harder than usual. Its chief value depends on the possession of a fairly well defined cleavage or parting which causes the mineral to break up into flat plates with sharp edges which tend to renew themselves by fracture during use. More usually garnet tends to break with a rough or conchoidal fracture and to wear round at the edges and such minerals have comparatively little value. For the same reason the fine rounded grains which occur abundantly in many streams have little value. Several tons of such material have been collected at Kamsandra which cannot be disposed of.

Various samples of Mysore garnets have been sent to England for valuation and in the majority of cases are reported to be of little or no value.

A large sample collected and washed from the Heggaddevankote Taluk was valued at £4 per ton, but as the cost of collection was considerably higher than this figure the licensee abandoned the work.

Garnets obtained from the Manjarabad Taluk under a

(¹) Records of the Geological Survey of India. Vol. XLVI, Page 271.

prospecting license are reported to have been valued at from Rs. 45 to Rs. 90 per ton in England, but as no further progress has been made it is probable that the work was not considered to be remunerative. It is very doubtful if there is any large demand for garnet for abrasive purposes outside the United States and it is very doubtful if the Mysore mineral would pay to extract, grade and put on the market in small quantities at current prices.

In recent years there has been a small output from Spain which, it is believed, can be produced at considerably less than the American figures quoted above.

MILL STONES.

. From several places in the Honnali Taluk, notably from Beesokalmatti—a hill north of Chik Gonigere—and from a hill north-west of Hosakoppa, large blocks of gritty schist are quarried and made into flat circular mill stones for grinding food stuffs and some of the finer grained varieties are used for whetstones. Larger blocks of tough calcite-chlorite trap are made into rollers for mortar mills near Basavapatna in the Channagiri Taluk. The work is carried on by the woddars of the Shimoga District and there is said to be a good demand for the stones in the Chitaldrug, Tumkur and Hassan Districts. In a Departmental report made in 1901 it was estimated that about 1,200 tons of stone, valued at Rs. 5,400, was used during the year in the Honnali Taluk. In the Hassan District certain varieties of potstone are stated to be used for mill stones and in Bangalore mill stones, road rollers and stones for mortar mills are made from selected portions of the granite and gneiss. In all these cases the materials are used to supply certain local demands, but none of them appear to possess any particular merits for high class grinding work and their use is chiefly a matter of local convenience.

(b) Refractory Materials.

MICA.

Character and uses.

The micas are essentially silicates of alumina and potash sometimes containing also magnesia, fluorine, lithia or soda. They are transparent flexible minerals occurring as flakes, sheets or thicker "books" and are capable of being split into indefinitely thin sheets owing to a very highly perfect cleavage. In colour they vary from white to red, brown and black.

The principal varieties are:—

Muscorite.—White to reddish brown;
Phlogopite.—Reddish or "amber" mica;
Biotite.—Black.

The two former are of commercial importance and represent the materials exported from India. The mica found in Mysore is muscovite which is usually dark coloured in thick books and light reddish brown in thin sheets.

Owing to its flexibility, transparency and infusibility it is used for lamp chimneys, stove doors, etc. Its chief use is however as an insulator for the manufacture of electrical machinery for which purpose it is necessary that it should be free from inclusions, spots and flaws.

The larger books are split to about the thickness of cardboard and the rough edges and flaws trimmed off with shears so as to give clean sound squares or rectangles with sides from one to two inches long up to several inches in length. Occasionally pieces over one foot square are obtained. The smaller pieces of irregular shape are trimmed to various round or oval shapes which are eventually split into very thin laminæ and cemented together with shellac to form large sheets known as "micanite." This artificial micanite yields a fairly good insulating material in lieu of large cut sheets, which are scarce and expensive, and has permitted the utilization of large quantities of scrap mica from the waste dumps of mines.

Some of the scrap mica produced by trimming and cutting of sheets is now finely ground and finds some sale for boiler and pipe lagging, fire proofing, lubricants, wall paper and paints.

Occurrence.

The micas occur in small flakes in many rocks chiefly those of a granitic or gneissic character. The larger books of commercial value are practically confined to large veins of coarse pegmatite which traverse or are asssociated with intrusions of granite and gneiss. In India the veins usually traverse mica schists or schistose gneisses, while in Mysore they are mostly in granitic gneiss. India is one of the most important mica producing countries of the world the chief centres of production being Behar and Orissa and Nellore.

In Mysore books of mica, up to 7 or 8 inches in diameter, have been found in several places, but the distribution is very erratic and much of the material is flawed or spotty and of rather low quality. The principal localities are the following:—

Hassan District.—The Kabbur Block (P. L. 350) near the 30th mile on the Yedatore-Hole-Narsipur road. At Sitapur hill, 6 miles S. W. of Hole-Narsipur.

Mysore District.—At Mundoor, 3 miles north of Saligram (P. L. 346.)

Two furlongs E. of Undivadi, near Kannambadi.

South of the 16th mile on the Kannambadi Road.

Near Vadesamudra—7 miles N. E. of French Rocks. (P. L. 436.)

Near Tagadur—7 miles E. of Nanjangud (P. Ls. 408 and 409.)

Sringeri Jahgir.—Near Kikri—It is reported that 23,568 lbs. of plates, rounds and splittings were obtained from about 180,000 lbs. of undressed mica, but not sold yet. Work has been abandoned for sometime.

Output. Attempts have been made, from time to time, to work some of these deposits and repeatedly abandoned owing to the irregular distribution of the mineral and the small quantity of saleable mica obtainable. It is probable that the amount of saleable mica recovered does not exceed 10 per cent of the total amount extracted.

Work is now being carried on at Kabbur, Mundoor and Vadesamudra.

The following Table gives the output to the end of 1914 the greater part of which has come from Kabbur. The output from the Sringeri Jahgir is not included.

TABLE 19—*Output and Value of Mica.*

Year	Quantity exported lbs.	Value at Madras Rs.	Value per lb.
1911 ...	2,028	876	6·91 annas.
1912 ...	5,062	2,303	7·28 ,,
1913 ...	1,000	994	15·90 ,,
1914 ...	5,477	2,514	7·35 ,,
Total ...	13,567	6,687	7·88 annas.

Value. Mica varies so much in size and quality that it is difficult to quote values which convey much information, while in Mysore the output has been so small and irregular and the grades so mixed that no very reliable figures are yet available.

The three principal producing countries are the United States, Canada and India and the following figures have been reported.

In the United States the value of sheet mica has been about 9 to 10 annas per lb. for the past 10 years and scrap mica Rs. 30-50 per ton.

In Canada the output is almost entirely Phlogopite or "amber" mica. The export value for the past few years has been from 12 to 15 annas per lb.

Indian mica from 1908-09 to 1913-14 has been valued at an average of 10 annas per lb. rising to 11 annas at the end of the period.

The Mysore mica sold in England has varied from 2 annas to Rs. 2½ per lb. for the various grades exported.

Consignments sent to Madras have averaged from about 7 annas to 1 rupee with a general average of 7·88 annas per lb. It is very doubtful if profitable work can be carried on at these prices unless some better deposits are found. Further work is contemplated at Vadesamudra and Kabbur and there is at any rate a possibility that the yield of saleable mica may be somewhat improved.

Asbestos.

Two distinct types of mineral are included under the commercial term "Asbestos." The most important is the mineral chrysotile—a hydrous silicate of magnesia—which is considered to be a fibrous form of serpentine. It occurs in narrow irregular veins in serpentine or other ultrabasic rocks the fibres of the mineral lying perpendicular to the vein walls. The veins are usually from ¼ of an inch to 2 or 3 inches in width and this determines the length of fibre obtainable. The greater part of the world's supply of this material comes from Canada. Very little has been found in Mysore and then only in very thin unworkable veins in serpentine. The other forms of asbestos belong chiefly to the varieties tremolite and actinolite of the amphibole group and are essentially anhydrous silicates of lime and magnesia.

Characters and use.

The value of asbestos depends on the facility with which the mineral can be broken up into fine fibres and on the length and strength of these fibres. Its usefulness depends very largely on the fact that the fibres are very infusible and consequently it is used very largely as a fire-proof or fire-resisting material. The longer and stronger fibres can be woven into fire-proof cloth and the shorter fibre, dust, etc., which is produced during milling is used for asbestos board, paper, tiles and plaster and also as a lagging or non-conducting covering for boilers, steam pipes, etc.

Occurrence.

So far none of the chrysotile variety has been found in Mysore in workable quantities but small veins have been noted in serpentine masses near Hole-Narsipur and Idegondanhalli in the Hassan District and near Shingammane in the Shimoga District.

The amphibole variety of asbestos has been noted in several places and appears to be an alteration product of various amphibolites or other ultrabasic rocks in proximity to intrusions of granite or gneiss. The following places may be mentioned:—

Chitaldrug District.—N. E. of Mayikonda village; fibres stained reddish brown and hard.

Near Budihal, Gangigere in the Hosdurga Taluk.

Kadur District.—In a coffee estate near Mudsosi, Mudgere Taluk.

Near milestone $\frac{4}{16}$ on the Belur, Mudgere road.

Hassan District.—On the Kabbur Block (P. L. 350).

Near the 30th mile on the Yedatore Hole-Narsipur road. Several tons have been obtained from here as samples and a fairly large quantity is said to be obtainable. The mineral also occurs near Hole-Narsipur, Sunnakal Hosur and Idegondanhalli.

Bangalore District.—A small quantity of a white asbestos has been found at Avalhalli about 2 miles from Bangalore on the Mysore road.

Mysore Ditrsict.—Small quantities have been found near Nagamangala and 2 miles S. W. of Mandya. The occurrence of a larger deposit has recently been reported near Konur about 12 miles south-east of Nanjangud.

The values vary very greatly according to quality. The different grades of material produced from the Canadian chrysotile deposits vary from about Rs. 900 to Rs. 27 per ton with an average value of Rs. 90 per ton. A large number of grades are produced from the same quarry during the process of mining and milling. The average amount of merchantable fibre produced is about 6 per cent of the total amount of rock excavated. The output from the United States is comparatively small and is of the amphibole variety and is valued at from Rs. 30 to 45 per ton. The Mysore mineral occurs in bunches and aggregates of fibrous material and at Kabbur long fibrous sticks of several feet in length can be obtained which can be picked out practically clean. The material can be easily fiberized and reduced to a white fluffy mass which should possess some merits as an insulator, steam pipe covering and where strength of fibre is not essential. The great defect in all the samples is the brittleness and lack of tenacity of the fibres and a sample of several tons sent to London failed to find a satisfactory market and was eventually sold at a little under Rs. 20 per ton.

Value.

The cost of the crude material delivered on the railways is said to be from Rs. 35 to 50 per ton.

The material obtained so far has all come from close to surface where the rock is much decomposed and this may account for the excessive brittleness of the asbestos fibre. In view of the increasing demands for asbestos it would be worth while to sink some of the pits deeper and ascertain whether the fibres become stronger while retaining sufficient facility for easy separation.

MAGNESITE.

Character and mode of occurrence.

Magnesite is the normal carbonate of magnesia ($Mg\ CO_3$) and occurs, from a commercial point of view, in two distinct varieties or types having very different modes of origin.

These types are sometimes distinguished by the terms "massive magnesite" and "crystalline magnesite."

The massive type only is found in Mysore and important deposits occur at Salem in the Madras Presidency and in the island of Euboea (Greece). Less notable deposits occur in many other countries.

This type occurs as a net work of veins in ultrabasic rocks of a serpentinous character derived from the alteration of dunites, peridotites, amphibolites, etc. The mineral probably results from the breaking up of the magnesian silicates by heated vapours or solutions containing carbonic acid with the production of magnesite which is deposited as veins in joints and fissures of the rock. A little of the silica is deposited with the magnesite in the form of chalcedony and the rest is removed in solution and may have been deposited elsewhere as quartz veins.

In Mysore the original ultrabasic rocks appear to have been intrusive dykes or masses in the Dharwar Schists and to have been intruded subsequently by portions of the Peninsular gneiss from which the heated solutions and carbonic acid were probably derived.

The magnesite is a hard white massive material with a rough to conchoidal fracture, something like broken procelain. Its value depends on the absence of impurities, particularly lime and iron, on the ease with which it can be separated from the enclosing rock and on the proportion of clean mineral obtainable to the total rock excavated.

The crystalline type of magnesite occurs only in Austria and Hungary and appears to be of the nature of a crystalline limestone or dolomite, of sedimentary origin, in which lime has been almost completely replaced by magnesia by subsequent chemical alteration.

For practical purposes the two types of magnesite are distinguished by the amounts of iron and alumina they contain and by their different behaviour during burning. As a commercial material the massive type contains less than 1% of iron oxide while the crystalline type contains some 3 to 6 % of oxides of iron and alumina. The former burns to a white material which is usually only lightly burnt or calcined ; the latter is always dead-burnt at a high temperature and yields a brown granular material which is used either as such or in brick form for furnace linings.

Distribution.

The various points at which magnesite has been found in Mysore are indicated on the enclosed map.

The principal deposits occur in the Mysore District between Mysore and Nanjangud. Of these the most important are at Dod Kanya and Dod Katur while other less important or poor deposits have been found near Shinduvalli, Talur, Solepur, Mavinhalli, Gurur and Kupya.

In the Hassan District relatively unimportant deposits have been found to the east and south-east of Hole-Narsipur and in the Arkalgud Taluk.

At Dod Kanya there is a patch of serpentinized rock, about three-quarters of a mile long by one quarter wide, which is much traversed by white veins of magnesite many of which appear on surface. The veins vary from mere threads up to several inches with occasional swellings up to several feet in thickness. From the prospecting work done it is seen that the veins tend to occur in two sets, one more or less vertical and the other horizontal or slightly inclined. Several of the larger masses belong to the latter set. It is probable that a considerable proportion of the whole mass would yield about one ton of magnesite for each 10 tons of rock excavated and that the total amount of workable magnesite would amount to several hundred thousand tons. The other deposits are less extensive or would yield lower proportions of mineral.

Composition.

A number of analyses have been obtained, chiefly from the Dod Kanya area (P. L. 404) and these are shown in Table 20 together with a few representative analyses from other places for comparison.

TABLE 20—*Analyses of Magnesite from Mysore and other localities.*

Serial No.	Insol. residue.	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	Remarks
			(Mysore samples)				
1	...	2·44	0·56		16·29	32·48	Surface material contaminated with Kankar. Dod Kanya.
2	2·82	...	0·57		6·56	40·88	,, ,, ,, ,,
3	...	5·64	1·18		1·24	43·52	Large sample from stacks ,,
4	1·78	...	0·07		0·45	46·49	Clean magnesite, 3 ft. below surface $\left(\frac{\times}{426}\right)$,,
5	3·60	...	0·12		0·48	45·25	,, ,, 6 ft. ,, $\left(\frac{\times}{425}\right)$,,
6	2·72	...	0·12		0·52	45·84	,, ,, 9 ft. ,, $\left(\frac{\times}{424}\right)$,,
7	0·75	...	0·12		0·35	47·12	,, ,, 12 ft. ,, $\left(\frac{\times}{423}\right)$,,
			(Foreign samples)				
8	...	0·29	...	0·65	0·83	46·42	Salem, India. Quoted by H. M. Dains, F.I.C., etc., in the Journal of Chemical Technology; 1912.
9	...	1·17	...	0·14	0·78	46·28	Salem, India. Quoted by H. M. Dains, F.I.C., etc., in the Journal of Chemical Technology; 1912.
10	...	1·63	1·19	0·17	1·44	45·75	Greecian ,, ,, ,,
11	...	3·10	0·30	0·80	...	...	Greecian ,, ,, ,,
12	...	3·24	2·97	1·14	0·82	42·80	Styrian ,, ,, ,,
13	...	0·92	...	4·30	1·68	42·43	Styrian ,, ,, ,,

At surface the Mysore magnesite is sometimes contaminated with lime kankar which raises the lime contents so high as to render the material useless for refractory purposes. The kankar is brown in colour and can be removed by dressing. A few feet below surface it disappears, but care has to be taken to clean the magnesite from serpentine, amphibolite and chalcedonic silica.

When properly dressed the Mysore material compares favourably with that from Salem and Greece.

USES OF MAGNESITE.

Raw Magnesite.

Raw magnesite is used in America for the production of carbonic acid gas (CO_2). The magnesite is heated in iron retorts thereby driving off the CO_2 which is collected and compressed in cylinders for the manufacture of ærated waters, etc. The residue in the retorts is calcined or caustic magnesia and is sold for the manufacture of refractory bricks, cement, plasters, etc. This use of magnesite as a source of CO_2 is said to be decreasing as the residual magnesia is often insufficiently burnt for the purposes for which it is required and unless it can be sold the manufacture of CO_2 in this way would not pay.

Magnesite is sometimes treated with sulphuric acid for the production of CO_2 and Epsom Salt is prepared from the residual solution. A note on this will be found in the section on the materials used for Agricultural and Chemical Industries.

Caustic Magnesia.

Caustic magnesia, also called calcined or lightly burnt magnesia, is obtained by burning magnesite in kilns in very much the same way as limestone is burnt to quick-lime. The burning may be conducted in bottle kilns with an admixture of coal, coke, wood or charcoal, but this has the disadvantage of introducing impurities from the ash of the fuel. Where purity is essential it is burnt in kilns with external fire-boxes or fired with gas. At Salem where high class caustic magnesia is produced the kilns are vertical, continuous feed, shaft kilns fired with producer gas made from Bengal coal. Magnesite is said to part with its CO_2 at a lower temperature than limestone, but much depends on physical character and on the amount of CO_2 which may be permitted to remain in burnt stuff. If the magnesia must not contain more than 2% of CO_2 the temperature requires to be 900° to 1000° C. for the Indian variety. After calcination the magnesia will absorb water and CO_2 from the air and will set into a moderately hard paste if slaked with water. The caustic magnesia is used very largely as a filling for paper and wood pulp and for the preparation of Sorel or "Oxychloride" cement for the production of which it is mixed with a strong solution of magnesian chloride. The cement is extremely hard and will carry several times as much sand or stone as lime or Portland cement and at the same time shows much greater resistance to crushing. It is said to be suitable for indoor work and to deteriorate on continued exposure to the weather.

It is used for the preparation of artificial stone, grindstones, mill stones, etc., and is mixed with sawdust, cork, asbestos, talc, etc., for the production of floor tiles, complete floors, etc. It is believed that most of the magnesia from Salem is sent to Europe for these purposes and the possibility of producing such a cement in Mysore for local use is worth attention. A good deal will depend on securing a suitable supply of magnesium chloride and the bitterns from the Madras Salt Works have been suggested as a possible source.

Dead burnt Magnesia.

In order to dead-burn magnesite the CO_2 has to be almost completely driven off so that not more than from $\frac{1}{2}$ to 1 % remains. In order to do this the temperature must be raised to from 1500° to 1700° C for which special kilns are required and a large expenditure of fuel. At this high temperature the magnesia shrinks and increases in density and will no longer absorb water or CO_2. In this form it is very refractory and is used as a basic lining for steel furnaces and electric furnaces. The principal supply of dead-burnt magnesia comes from Austro-Hungary where the deposits of crystalline magnesite contain much more iron and alumina than the Indian and Greecian varieties. Owing to its physical character and composition the former can be dead-burnt at a temperature of 1500° C in continuous bottle kilns using producer gas or in rotary kilns using powdered coal. The resulting material clinkers or frits so that it is obtained in a granular form which can be thrown on to the bed of the furnace without getting blown away and it then frits together into a solid mass. Also, if moulded into bricks and fired it fuses together sufficiently to form hard strong bricks suitable for furnace work. It is still a very refractory material and for the above reasons there is a large demand for it for basic linings.

When we come to the massive variety such as occurs in Greece, Salem or Mysore a different problem is presented. The temperature required is much higher—about 1700° C-and this will probably necessitate special kilns of a regenerative type. Attempts to produce dead-burnt magnesia at Salem are understood to have been unsuccessful. Again, the material does not frit together, but falls into fine powder in which form it is unsuitable for furnace lining or manufacture of bricks. It is believed, however, that bricks are made from it for electric furnaces and that they are more refractory than those made from the Austrian magnesite; on the other hand they are brittle and would not stand the mechanical strains of open hearth furnaces. The problem of using Mysore magnesite for this purpose has been under investigation in consultation with the Tata Iron and Steel Works and the most practical solution appears to be to grind either the magnesite or calcined magnesia with a small quantity of iron oxide thereby reducing its infusibility and permitting it to frit to a material which can be used in a granular form or made into bricks. Experimental work has shown that good bricks can be thus made and the outstanding questions are those of cost and location of work.

From the prospecting work done on the Dod Kanya block it is probable that the cost of mining and sorting the magnesite will lie between Rs. 3 and Rs. 5 per ton of magnesite exclusive of supervision.

Cost of Mining.

It is very difficult to give any estimates of cost without a definite proposition as to quantities and character of the product required. The following figures may, however, be of some use to those who have the matter under consideration. The amount of coal required is about 20 to 25 % of the calcined magnesia, say about Rs. 5 per ton of calcine. If wood could be used the cost would be slightly less.

Cost of Calcining in Mysore.

TABLE 21—*Estimated cost of calcining magnesite in Mysore.*

Output 50 tons of caustic magnesia per month	Rs.	a.	p.
$2\frac{1}{4}$ tons of magnesite at Rs. 4	9	0	0
Coal	5	0	0
Labour for burning	6	0	0
Bags and bagging	6	0	0
Supervision	5	0	0
Interest and upkeep of kiln	2	0	0
Royalty, rent and sundries	5	0	0
Total per ton of magnesia ...	38	0	0

This is a very rough estimate and the charges for supervision might have to be greatly increased if a high grade standard product was required. On the other hand, if the output was materially increased to a few thousand tons a year the cost would come down to about half the above figure at which rate it might be just possible to place some on European markets.

Cost of dead burning.

Little precise information is available at present on this point. Either the magnesite or calcined magnesia would have to be ground and mixed with iron ore and then bricquetted and dead-burnt. Rotary kilns would not be desirable unless the output was large. The amount of coal required would probably be about 15 cwts. costing, say, Rs. 15, and the total cost of making dead-burnt magnesite in Mysore is likely to lie between Rs. 50 and Rs. 80 per ton. The cost of the Austrian material imported into India before the war was about Rs. 65 per ton.

It is doubtful if the dead-burnt material could be supplied to the north of India from Mysore as cheaply as it can be imported unless the output is large and the demand does not justify this at present. On the other hand, it is quite possible that manufactured bricks could be delivered at a lower rate than the imported article owing to higher packing and transport charges, etc. This point is still under investigation.

OTHER REFRACTORY MATERIALS.

Chromite.

Chromite, or Chrome Iron Ore, is in some demand as a refractory lining material for furnaces. The occurrence and distribution of the ores have been described already under Chromium. For furnace lining the ore is preferred in large lumps or brick-like blocks and it is believed that bricks are also made from the crushed powder. During the past year or so a regular supply of high grade Chrome Ore has been sent to the Tata Iron and Steel Works from Kadakola in Mysore. It is thought that there may be some use also for the lower grade ores from Arsikere in lump form and attempts are being made to find a market.

Potstone.

Potstone, or soapstone, is a soft tough greenish to grey rock composed largely of the mineral talc. It usually contains varying proportions of mica, chlorite, serpentine, amphibole and pyroxene and the amount of the accessories or impurities determine the quality of the stone.

The fine, light coloured and comparatively pure soapstone which is used for gas-burners, production of talc powder, etc., has not been found in Mysore. The coarser textured greenish material is used locally for the manufacture of pots, pans and other fire-resisting utensils, but the most extensive use is as an ornamental building stone where intricate and delicate carving is required. Other uses are as electric switchboards and insulators and in the form of fine powder for cotton sizing, paper filling, lubricant, etc., but the suitability of the Mysore materials for these purposes has not been ascertained and the greater number of samples would appear to contain too much gritty material.

Varieties of potstone are widely distributed chiefly in the region between Arsikere and Hassan.

In the Shimoga District it is found :—

Near Saulonga, Kudli and Hoskoppa in the Honnali Taluk.

Near Kavaledurga in the Tirthahalli Taluk and near Benkipur.

In the Chitaldrug District near Lokadalalu and Audanur in the Holalkere Taluk.

In the Tumkur District on a ridge close to Kadehalli, Turuvekere Taluk. Less altered parts of this are a rather hard rock (amphibolite) which takes a fine black polish and has been largely used in the Palace at Mysore and at Tippu Sultan's Tomb, Seringapatam.

In the Mysore District—near Chattanhalli, Talur and Kadakola in the Mysore Taluk—at Manhalli in the Heggaddevankote Taluk and at numerous other places of minor importance.

Fire Clay.

No deposits of what can be properly called fire clay are known to exist, but some of the decomposed pegmatites, granites and gneisses—which now consist largely of quartz and kaolin—and some of the more or less impure masses of kaolin and lithomarge would no doubt yield fire bricks of fairly refractory quality. Bricks of this character have been made at the City Brick and Tile Works, Bangalore, from decomposed pegmatite veins in the gneiss near Golhalli. This decomposed material contains about 30% of kaolin the remainder being quartz and sundry impurities. If care is taken to select material fairly free from iron, a good firm fire brick can be obtained by the addition of a small proportion of more plastic clay. In many parts of the State, materials of this character can be obtained from which local demands could be supplied. The material is not sufficiently valuable to stand long transport, but several small brick and tile works are in existence or projected and in most cases it should be possible to obtain some kaolinic or lithomargic material within a reasonable distance of the work. Local demands are not likely to be large and any export to surrounding areas would depend on the quality of brick which can be produced—a matter which requires further practical investigation. A number of localities in which various grades of kaolinic material have been noted will be found in the section on kaolin.

(c) Mineral Pigments.

OCHRES, OXIDES, AND COLOURED CLAYS.

The ochres are composed largely of hydrated oxides of iron mixed with more or less clayey or gritty material. They may occur as fine sediments deposited by water or as the residual products of schists, iron ores or limestones which have been subjected to long continued weathering and chemical alteration.

In colour they present various shades of yellow, brown and red and usually require to be ground finely or crushed and levigated with water so as to produce an extremely fine textured material of uniform colour which can be used for colour washes, distempers or oil paints.

Ochres of sorts occur in many places in Mysore more particularly among the iron ores, manganese ores and limestones of the Chitaldrug Schists.

Recently some prospecting licenses have been taken out in the neighbourhood of Chik Kittadhalli and Kenkere and some large samples have been taken out for experimental treatment with a view to testing the markets.

The Mysore ochres though fine in texture, when levigated, and of good body are generally dull in colour. Small quantities of fairly good yellow and red have been found, but they are usually much mixed with other material which would render clean extraction difficult and expensive. Large quantities of the duller colours can doubtless be obtained—chiefly a rather brownish-green yellow, various shades of brown or umber and dull brick red or terra cotta. If burnt the yellow material yields a pleasing reddish-brown oxide. The materials at present under investigation are disadvantageously situated owing to distance from a railway and a lack of a convenient supply of water for washing in both of which respects improvements might be made if the products were found to be marketable. A further difficulty which has to be faced is the question of packing. If the material could be sent away in the raw state, this difficulty would not arise, but if prepared and in a very fine state it is generally required to be packed in kegs or casks which would be difficult to procure in Mysore and expensive. Possibly double bags might be used.

So far it has not been possible to ascertain very definitely the probable market values of the materials and the only way to get at this will be to prepare fairly large quantities and place them on the market.

Samples have been sent to Bombay and were not very favourably reported on. In normal times the prices in Bombay would seem to run from Rs. 2 to Rs. 4 per cwt. packed. At the present time the prices might be up to Rs. 4 to 6, but it is doubtful if there would be much demand for dull colours.

Samples sent to England are said to be worth from £3 to £5 per ton in normal times, but no very strong demand. Even at the higher price it is not likely that they could be exported at a profit.

On the other hand there is some local demand in Mysore both for the dry powder and mixed with oil as paint and the local prices are likely to be considerably higher than those quoted above. There is also some demand in Madras at prices which are stated to vary from Rs. 5 to Rs. 7 per cwt. in normal times and up to Rs. 15 at the present time.

The fact that prices are now high makes a favourable opportunity for the experimental production of large samples in order to obtain more precise information as to costs and market requirements and values and work on these lines is being proceeded with by the present licensees.

(d) Materials used for Agriculture, Chemical Industries and Food.

Many minerals are used for the preparation of manures and fertilizers and for the preparation of various chemicals used in industrial processes. Brief notes on a few of these are given below and the list might be largely extended. The notes are meant to be suggestive and to show the relative value of various factors which determine whether certain materials can be used or manufactured commercially at a profit. The estimates of cost, etc., are of a very general character and must be varied to suit specific cases and on many points rough assumptions have had to be made owing to lack of more precise information.

Proposals are constantly being put forward for the establishment of small chemical industries based on the fact that some of the raw materials exist in Mysore. It will be seen however that the raw materials often form a relatively unimportant part of the total cost of production and marketing and this is more particularly so in the case of small industries. Where the output is small the charges for supervision, interest, depreciation, etc., are relatively large. When the output is large these overhead charges diminish considerably and small advantages or reductions in cost of the raw materials begin to make themselves felt. It must not be forgotten also that many of the materials used in the production of chemicals and chemical products are themselves bye-products of other industries and that in the absence of any supply of, or demand for, bye-products work could not be carried on profitably however feasible it might be from a technical point of view.

PYRITES.

Iron Pyrites is a yellow mineral of the composition $Fe\ S_2$, containing 46·6% of iron and 53·4% of sulphur, and is widely distributed in the rocks of Mysore in grains and crystals. The quantities present are usually very small, but in some of the chloritic and talcose schists of Chitaldrug and Shimoga and in some of the auriferous veins and lodes the proportion of pyrites present rises to noticeable amounts which may vary from 5% to 20% of the rock. Nothing in the shape of a high grade deposit containing 50% or more of pyrites has been found and, from a commercial point of view, the mineral would not deserve notice here were it not for the suggestions which have been so frequently put forward that Mysore contains valuable deposits which might be used for the local manufacture of sulphuric acid.

Amongst the most noticeable deposits which have been found are some bands or zones of veined schist amongst the old workings at Honnehatti and the quartzose ore of the Jalagargundi Mine. These have been described in the section on gold (pp. 48 and 50). In the former the zones carrying pyrites are small and very patchy and the mineral is mixed with copper pyrites and blende. In the case of Jalagargundi there is a wide lode richly studded with variable amounts of clean iron pyrites and for the sake of illustration a test was made with a picked sample of the richer portions. The sample was crushed and concentrated and the pyritic concentrate was found to amount to 20% of the rock and to contain 46% of sulphur. These richer portions could not be mined separately and the average contents of the lode would probably lie between 5% and 10% of pyrites.

For the sake of example we may take the favourable view that a considerable amount of material containing 10% of pyrites could be mined at reasonable cost. As the output would be small, it would be a low estimate to put the cost of mining, crushing and concentrating the rock at Rs. 10 per ton and, as 10 tons of rock would be required for 1 ton of pyrites, the pyrites would cost Rs. 100 per ton at the mine.

We may now consider how much a sulphuric acid works could afford to pay for pyrites. It should be possible to deliver Spanish Pyrites at a works in Mysore for some Rs. 50 to 60 per ton and to deliver Sicilian Sulphur at Rs. 100 per ton or less and Japanese Sulphur at a still lower figure. Of these materials sulphur would be more economical than pyrites.

If therefore we can get sulphur at Rs. 100 or less, the relative value of the Mysore pyrites (containing 46% of sulphur) would be Rs 46 per ton or less. As, according to the above example, it costs Rs. 100 at the mine, the proposition is not commercially feasible. Even if we could find an ore containing 20% of pyrites, it still would not pay in competition with imported sulphur.

The only hope of being able to use Mysore pyrites would be the development of a gold mine in which the pyrites would be obtained as a bye-product and could be sold cheaply and this is not without the bounds of possibility, though its advent is not at present in sight.

SULPHURIC ACID.

Cheap sulphuric acid is an extremely important factor in many chemical industries and the desirability of manufacturing it in Mysore has often been discussed and advocated. We have shown that local supplies of pyrites are out of the question, at any rate at present, in comparison with imported sulphur.

The problem of producing sulphuric acid in Mysore more cheaply than it can be imported depends entirely on the local demand for it. The extent of this demand is not very accurately known, but Bangalore probably imports 100 to 150 tons of concentrated acid a year and there may be a small additional import to other places. It is probable that the total demand does not exceed half a ton per day on the average.

How far it would be technically feasible to erect and work a plant to produce only half a ton a day is doubtful and the profit to be obtained, if there was a profit, could not amount to very much.

We may more usefully consider the case of a small unit to make 4 to 5 tons a day of concentrated acid. This would be capable of turning out about 1,900 tons of chamber acid, or 1,200 tons of concentrated acid per year, or partly one and partly the other.

Plant and erection would cost about one lakh, buildings and bungalows half a lakh or so and half a lakh for sundries and working capital. On this we might allow a depreciation of 15% on the plant, 5% on buildings and 5% interest on the total.

Supervision, office, laboratory and labour might be put at Rs. 3,500 per month of which skilled supervision forms the greater part and would be independent of the quantity produced within wide limits.

Materials required per ton of chamber acid would be as follows:—

	Rs.	a.	p.
4½ cwts. sulphur at Rs. 5	22	8	0
3 cwts. coal at Re. 1	3	0	0
Nitric acid and sundries	9	8	0
Total ...	35	0	0
For one ton of concentrated acid we require.—			
1·6 tons chamber acid at Rs. 35 ...	56	0	0
4 cwts. English coke at Rs. 40 per ton ...	8	0	0
Sundries	4	0	0
Total ...	68	0	0

TABLE 22.—*Approximate estimates of cost of sulphuric acid.*

	tons per year 1,900		
Chamber acid	Rs.	a.	p.
Materials	35	0	0
Supervision and labour	22	0	0
Depreciation	9	0	0
Interest	5	0	0
Total per ton ..	71	0	0
Concentrated acid.—			
Materials	68	0	0
Supervision and labour	35	0	0
Depreciation	15	8	0
Interest	8	8	0
Total per ton ...	127	0	0

One anna per lb. is Rs. 140 per ton and the above rough estimates appear to show that chamber acid could be made here for ½ an anna per lb. and concentrated acid for a little over ¾ anna per lb.

Concentrated acid can be imported into Bangalore, packed in jars, at something between 1½ and 2 annas per lb. so that for sale or use in Mysore the locally made acid should have a fair margin in its favour. The figures depend entirely on the quantity, *viz.*, about 1,200 tons per year, and as the present demand probably does not exceed 150 tons there is a long way to go before these favourable conditions can be realized.

If the plant worked part time so as to produce only 150 to 200 tons a year, the cost would go up to about 2 annas a lb. or perhaps more. If a less costly plant was feasible and the staff could be employed on other chemical work for part time, the cost might come down to something between 1 and 2 annas a lb. and the profits, if any, would be small.

Further uses for sulphuric acid may be developed and if the output rises to several tons per day it can be manufactured locally more cheaply than it can be imported. The essential question in each case will be whether the article to be manufactured can stand a charge of even ¾ anna per lb. for sulphuric acid or whether it would not be more cheaply manufactured by transporting the other ingredients or materials to Madras or elsewhere where the acid could be made still more cheaply in larger quantities. Each case has to be considered on its individual merits and the following may be taken as an illustration.

EPSOM SALT.

There is a certain demand for crude Epsom Salt in India part of which is satisfied by manufacture in India. Pre-war prices have been quoted at Rs. 3 to 4 per cwt. in Bombay and up to Rs. 6 or 7 in Madras. At present (1916) prices may be from Rs. 10 to 13 per cwt.

It has been suggested that the Mysore magnesite should be utilized and some excellent samples of Epsom Salt have been prepared in the Chemistry Department of the Indian Institute of Science, Bangalore.

The commercial aspect may be roughly summarized as follows:—

Epsom Salt ($MgSO_4$, 7 H_2O) contains about 16½ per cent of magnesia (MgO) and the Mysore magnesite contains about 45 per cent of magnesia.

One cwt. of Epsom Salt requires approximately:—

42 lbs. of magnesite.
47 lbs. sulphuric acid.

The cost of these materials in Bangalore may be put at:—

42 lbs. magnesite at Rs. 15 per ton=4½ annas.
47 lbs. sulphuric acid at 1½ to 2 as. per lb.=Rs. 4-4-0 to Rs. 6.

The raw materials amount therefore to from Rs. 4-8-0 to Rs. 6-4-0 per cwt. of Salt and the latter figure or higher would apply at the present time. These figures more or less correspond to the quoted sale values in normal times and leave little or nothing for costs of manufacture, transport and profit.

Another useful way to consider the matter is to compare the effect of taking the magnesite to Bombay or Madras and doing the work there. This would add some 4 to 12 annas to the cost of the magnesite, but the sulphuric acid would probably be reduced to ½ or ¾ anna per lb. and the total cost of raw materials would be 2 or 3 rupees less per cwt. of Salt than in Mysore and competition seems out of the question.

It has been suggested that makers of aerated waters might use magnesite instead of sodium carbonate, with sulphuric acid, for producing carbonic acid and sell the resulting Epsom Salt as a bye-product. They may be prepared to consider this, as the value of the Epsom Salt would largely pay for the sulphuric acid while the increased cost of manufacture would be offset by the saving in cost of magnesite as compared with sodium carbonate.

If local demand and production of sulphuric acid can be developed so as *to bring its cost down to about ½ an anna per* lb., the position would be materially altered.

LIME.

Lime is said to be required by many of the Mysore soils and a note on the prospects of obtaining crushed limestone or burnt lime for agricultural purposes will be found in the Section on Limestone. (pp. 177 and 181.)

The mineral *Apatite*, which is a phosphate of lime, is much sought after as a source of superphosphate for agricultural use for which purpose it is collected and treated with sulphuric acid which decomposes it into gypsum and calcium superphosphate. It occurs as an accessory mineral in many rocks, but no commercially valuable occurrence has been located in Mysore. About 5 miles east of Channarayapatna, Hassan District, a small vein, about 9 inches thick, of the mineral was found many years ago, but the quantity was insignificant and no further supplies have been found.

Large quantities of lime are now being used in America and Europe for the production of calcium carbide and calcium cyanamide. The latter, which in its commercial form is called "nitrolim" or "lime-nitrogen", is used directly as a fertilizer and might prove of considerable use in Mysore where the soil is deficient in lime. Dr. Coleman, Director of Agriculture, and Mr. H. V. Krishnayya, Chemist to the Departments of Geology and Agriculture, have been making enquiries and experiments on this point and the possibility of obtaining the materials and making the cyanamide in Mysore has been referred to this Department for opinion.

The following note has been prepared on the scanty information available here and further enquiries are being made.

Calcium Cyanamide.

For many years the world has been supplied with enormous quantities of sodium nitrate from the celebrated deposits in Chile. This material is valued mainly on account of its nitrogen and is used largely as a fertilizer as well as for the production of nitric acid and ammonia. It is recognised that the deposits are by no means inexhaustible and that with the increasing demand for fertilizers for agricultural purposes the supply of nitrogen from this source cannot be expected to last for many years. Much attention has therefore been paid to the artificial production of compounds containing nitrogen in a form suitable for agricultural purposes and of these the principal source, which is an increasing one, is the utilization of the ammonia which is produced as a bye-product during the distillation of coal for the production of gas and coke. The ammonia is converted by the aid of cheap sulphuric acid to ammonium sulphate in which form it is used as a fertilizer.

Fixation of atmosphere nitrogen.

In recent years numerous, more or less successful, attempts have been made to extract nitrogen from the atmosphere in which it exists in practically unlimited quantities, and to fix it in combination with other elements in a form suitable for distribution and use as a fertilizer. Two main types of processes are employed, *viz.*:—

(1) The direct combustion of the nitrogen and oxygen of the atmosphere in the electric arc which results in the formation of various oxides of nitrogen which are converted subsequently into nitric acid; and

(2) The combination of the nitrogen of the air with metals or carbides of which one of the most important products is *Calcium Cyanamide*.

Of the first group or arc processes it is not necessary to say anything here. The efficiency of these processes is stated to be very low and relatively large amounts of very cheap electric power are required. Under present conditions it would seem that they can be conducted on a commercial basis only in places such as Norway where abnormally cheap power can be obtained in large quantity. The comparatively high rates obtainable in Mysore, even under the most favourable conditions, would seem to create an insuperable bar to the adoption of any such processes here.

In the case of the cyanamide process the amount of power required is very much less, per unit of nitrogen combined, than in the arc processes and a higher rate for power is permissible. It may be worth while therefore to discuss briefly the general features of this process under conditions which may be expected to obtain in Mysore.

The process may be outlined as follows, but the reactions are by no means as simple as the equations given would seem to suggest. A mixture of burnt lime and coke is heated in electric furnaces with the production of *Calcium Carbide*.

Carbide.

$$\underset{\text{(lime)}}{CaO} + \underset{\text{(carbon)}}{3C} = \underset{\text{(carbide)}}{CaC_2} + CO$$

The carbide is very finely ground—an operation which is attended with considerable risk of explosion—and is brought into contact with

Cyanamide.

nitrogen obtained from liquid air. The reaction takes place in small retorts and the product is *Calcium Cyanamide*, or "nitrolim" as it is sometimes called. The reaction may be outlined thus:—

$$CaC_2 + 2N = \underset{\text{(cyanamide)}}{CaCN_2} + \underset{\text{(graphite)}}{C}$$

A number of other reactions take place and the commercial cyanamide or nitrolim is said to contain 57 to 63 per cent cyanamide; 14 per cent graphite; 20 per cent lime and 7 to 8 per cent silica and oxides of iron and aluminium. The total nitrogen content is 20 to 22 per cent.

The Cyanamide is ground and treated in various ways and placed on the market as a fertilizer.

Ammonia.

Ammonia can be produced at a small additional cost, by subjecting wet Cyanamide to heat and pressure thus:—

$$CaCN_2 + 3H_2O = \underset{\text{(ammonia)}}{2NH_3} + CaCO_3$$

Value.

Cyanamide for fertilizing purposes is quoted in Madras at about Rs. 180 per ton and we may now consider, with such general information as we have at our disposal, whether there is any prospect of commercial production in Mysore and the main controlling factors and points on which further information is required.

Raw Materials.

It is stated that very high grade carbide is required and this means the use of high grade lime and coke. As pointed out in another section, we know of no high grade limestone in Mysore and it is not known whether the lime which we could produce—containing about 85 per cent of CaO—could be economically used or whether the resulting carbide would nitrify satisfactorily. It would, at any rate, be less economical than a purer material and the final cost per unit of nitrogen fixed would rise accordingly. The next point is the supply of carbon. We have no coal or coke in Mysore and Indian coke would be expensive and impure. On the other hand we have charcoal, the purity of which is very high, but it is not known if it could be used for making carbide. We believe that charcoal has not been used hitherto, but it is probable that a suitable process and furnace could be devised.

Power required.

The most important factor of cost is that of electric power and it is stated that Cyanamide cannot compete in Europe with other nitrogen fertilizers if the power costs more than £3 per H. P. year. In Mysore power costs about £10 per H. P. year, but it is possible that in future some surplus power may be available at much cheaper rates in the neighbourhood of the generating stations. We understand that about $\frac{3}{4}$ of a H. P. year is required for the production of a ton of carbide and a total of about $\frac{1}{2}$ a H. P. year, or 3,267 K. W. hours, for a ton of Cyanamide. For the purpose of a rough estimate we assume that about $\frac{2}{3}$ of a ton of lime and $\frac{1}{2}$ a ton of charcoal will be required per ton of Cyanamide.

Materials and power would be as follows :—

	Rs.
3,267 K. W. hours at 0·2 annas per unit ...	41
electrodes	10
$\frac{2}{3}$ ton of lime at Rs. 21	14
$\frac{1}{2}$ ton of charcoal at Rs. 25	12·5
Total ...	77·5

If power was available at 0·1 anna per unit this total would reduce to Rs. 57 and these figures show clearly the supreme importance of the power charges.

Cost of Production.

A plant to produce 10,000 tons a year would require 5,000 H. P. and though we have little information to go on we may assume some figures for other essential items and frame the following tentative estimate.

TABLE 23.—*Rough estimate of cost per ton of Cyanamide.*

	Rs.
Power	20·5 to 41
Materials	36·5
Labour	20
Supervision and Management	5
Interest and depreciation	15
Repairs, sundries, etc.	10
Total ...	107 to 127·5

If the value of imported Cyanamide remains at anything like Rs. 180 a ton it looks as if there might be some chance for a local production if the cost of power can be kept within the limits indicated. We must remember however that owing to the impurities in the limestone the resulting product will be lower in nitrogen and less valuable than the imported article, perhaps 20 to 25 per cent lower, and that we have still to find out whether it is possible to make a saleable product at all with the materials at our disposal. The subject is at any rate worth attention and even if our lime should prove quite unsuitable for this purpose the cost of lime is such a small item that it might be possible and even advantageous to import a high class lime for the purpose.

EARTH SALT AND EARTH SODA.

Salt.

An impure salt is prepared in many parts of the State from the saline alluvium and soils which are found along water courses and in tank beds, chiefly in the gneissic country. These saline materials occur in many parts of the State and chiefly along the course of the Vedavati river and its tributaries in the Chitaldrug and Tumkur Districts and along the Mugur river in the Gundlupet Taluk of the Mysore District.

The salt earth is collected chiefly during the dry months of the year between January and April and is lixiviated with water in wooden tubs or vats. The brine is run off into shallow pans in which the salt crystallizes out as the water is evaporated by the sun.

The salt finds a local market and is usually fairly impure containing variable amounts of soda, lime, magnesia and clay or sand. The production is variable and usually small and probably does not exceed a few hundred tons in a year. The price varies according to quality from about Rs. 2 to Rs. 10 per cwt., the average being about Rs. 3 or 4.

Soda.

In some places there is a saline efflorescence which is distinctly alkaline owing to the presence of sodium carbonate. The principal localities are in the neighbourhood of Mandya and in the Taluks of Hosdurga, Hiriyur and Challakere. The best material occurs as a thin white efflorescence which appears on low lying ground which has been saturated or water-logged during the rainy season. The surface layer carrying the efflorescence is scraped off during the months of January and February and may contain from 5 to 12 per cent of sodium carbonate with varying amounts of sodium chloride, the remainder being sand. This material is known as *dhoby's* earth and is used for washing clothes. Some years ago this earth used to be lixiviated with water and the solution evaporated in shallow pans made of clay or chunam smoothed over with cow-dung. Successive solutions were poured into the pan and evaporated until a cake, about ½ an inch thick, was formed. This was then broken up and sold as soda cake. For some years past the production of soda cake in Mysore has been abandoned, but considerable quantities are imported from the Anantapur District. A sample of this cake (*Vide* Table 24, No. 1) gave about 40 per cent of sodium carbonate and 20 per cent of salt and is fairly impure.

The cake is said to be worth Rs. 2-2-0 to 2-4-0 per cwt. at Penukonda and Rs. 4-0-0 to 4-8-0 in Bangalore. The increase in price for Bangalore seems very high even allowing for packing and transport and it is difficult to understand why it should command such a high price when good imported soda ash can be obtained for about Rs. 5 per cwt.

A number of samples of the earth have been collected departmentally from the Mandya area and these are being experimented with in the Chemistry Department of the Indian Institute of Science. A number of analyses kindly furnished by the Institute are given in Table 24 and the following information about them may be of interest.

Numbers 2 and 3 were collected from small areas in the month of December and represents the fresh incrustation after the previous rains. In collecting it some sand is necessarily taken up and samples show from 6½ to 12 per cent of sodium carbonate ($Na_2\,CO_3$) with remarkably little salt ($NaCl$). This result was interesting and encouraging and further samples were obtained from a much wider area, during March, most of which have not been dealt with yet.

Numbers 4 to 7 form a series from one place by taking off successive layers of material. It will be seen that the bulk of the soda is in the top layer, one inch thick, and that there is considerable concentration in the topmost crust which averages about ⅛th of an inch in thickness.

It is noteworthy that the relative proportion of salt has greatly increased in comparison with samples 2 and 3. The significance of this has not been determined, but it is stated that the top soda-bearing layer had already been removed once, earlier in the year, and that there is a tendency for the subsequently formed incrustation or efflorescence to contain relatively more salt. In fact there are a number of salt pans in the area and the earth or sand is used for production of salt after the top layer has been removed for use as earth-soda.

Sample No. 8 represents about 2 tons of surface scrapings collected during March. It is possible that had the samples been collected earlier in the season the proportion of salt would have been lower.

TABLE 24—*Analyses of Alkaline Earth.*

Serial No.	Registered number	Na_2CO_3 per cent	NaCl per cent	Insoluble per cent	Organic per cent	Moisture per cent	Remarks
1	O/1045	40·40	19·70	20·50	1·50	17·50	Soda cake from Penukonda.
2	X/524	6·57	0·51	90·00	0·18	2·65	Surface incrustation about $\frac{1}{4}$ to $\frac{1}{2}$ inch thick from Chinnanhalli near Mandya.
3	X/525	11·75	0·43	83·00	0·29	3·75	Surface incrustation about $\frac{1}{4}$ to $\frac{1}{2}$ inch thick from Punakanhalli near Mandya.
4	R_2/4	12·0	15·2	...	...	...	Surface crust $\frac{1}{8}$ inch thick. Field near Mandya.
5	R_2/5	4·7	3·0	...	...	...	Next layer below, $\frac{3}{4}$ inch thick. Field near Mandya.
6	R_2/6	0·26	0·22	...	...	...	Next layer below, 2 inches thick. Field near Mandya.
7	R_2/7	0·11	0·02	...	...	...	Next layer below, 2 inches thick. Field near Mandya.
8	R_2/20	5·46	2·62	...	...	...	Surface scrapings $\frac{1}{2}$ to 1 inch thick. General sample from a number of localities round Mandya. Samples 2 and 3 collected about middle of December. Samples 4 to 8 collected about middle of March.

There is evidently room for much further enquiry as to the conditions of occurrence and the composition. In the meantime advantage will be taken of the facilities afforded by the Institute of Science to have a bulk test made of the product obtainable from No. 8.

It has not been possible to obtain any reliable information as to the amount of alkaline earth annually available. In a few places from 100 to 200 cart loads are said to be removed per annum and altogether the Mandya area might yield one or two hundred tons of the earth a year. If we take an average recovery of 5 per cent of sodium carbonate the latter would amount to some 5 to 10 tons. This is at present a mere guess, but it is hoped to get further information. The chief difficulty to be faced will be the proper collection of material and the expense of carting small lots from a radius of several miles and we cannot say at present whether these will prove prohibitive features.

III. Materials for Construction, etc.

LIME KANKAR.

Lime kankar is a concretionary form of carbonate of lime ($CaCO_3$) and occurs in the form of irregular nodules or nodular veins on the weathered surface of gneiss or schist and in joints and fissures to a depth of several feet. As a rule, it is not associated with limestone, but a case has been reported from Voblapur where the surface of a limestone bed has been converted into a sort of porous kankar. Ordinarily it appears to owe its origin to the weathering of gneiss or schistose traps whereby the lime silicates are broken up and the lime taken into solution by carbonated waters from which the carbonate of lime separates out at or near surface in nodular concretionary forms. As might be expected the kankar is usually impure and contains included sand and gravel. When excavated and picked out in large quantities the quality of the kankar depends very much on the care with which the nodules are sorted from decomposed rock and soil and the grade of the material is very variable and usually much below that of carefully selected samples.

The material is very widely distributed and may be found in most taluks where it is collected and burnt in small pot kilns and used locally for whitewashing, mortar, etc. Various analyses are given in Table 25 and referred to below by their serial numbers. In some places large quantities have been obtained and exported. Of these some of the principal are in the Mandya Taluk. From Sindlagiri (No. 1) it is reported that 50 or 60 waggons used to be railed to Bangalore every month and also considerable quantities from the banks of the Hebhalla. The kankar was mostly of poor quality and the supply of good material now available is said to be small and

TABLE 25.—*Analyses of kankar from the Mysore State and from Salem (Madras Presidency).*

Serial No.	Registered No.	Moisture %	Loss on ignition %	Insoluble residue %	SiO_2 %	SiO_2 soluble %	Fe_2O_3 %	Al_2O_3 %	MnO %	CaO %	MgO %	S %	P %	Locality
1	0—210	...	32·00	...	24·78	...	1·55	4·47	...	25·90	10·46	0·048	0·004	Sindlagiri, Mandya Taluk.
2	R- 172	0·87	36·82	...	9·03	...	2·35	1·08	0·10	45·85	4·12	0·023	0·006	Samalpatti, Salem Listrict.
3	R—173	0·90	35·55	...	10·93	...	2·58	2·43	0·074	43·82	2·80	0·024	0·002	Morappur, Salem District.
4	0—208	...	41·94	...	4·58	...	0·96	1·51	Trace	45·60	6·38	0·039	0·002	Mardevanhalli, Mandya Taluk.
5	0—209	...	42·28	...	2·70	...	0·85	0·76	Trace	52·70	1·17	0·028	0·005	Malchakanhalli, Mandya Taluk.
6	C—46	0·755	CO_2=37·803 H_2O=1·880	6·67	...	...	2·93	...	...	49·13	Trace	...	...	Marikanave.
7	0—620	0·70	38·39	4·96	...	3·32	3·18	...	...	48·30	0·99	...	...	Vicinity of Kannambadi, Krishnarajpete Taluk.
8	0—621	0·32	33·11	9·45	...	2·57	5·46	...	...	36·69	8·03	...	...	Do
9	0—622	0·42	38·39	6·84	...	3·07	4·29	...	...	44·73	2·44	...	...	Do
10	0—623	0·44	36·40	10·05	...	3·63	4·11	...	...	40·89	4·50	...	...	Do
11	0—624	0·84	34·11	12·17	...	3·12	6·60	...	...	41·28	0·96	...	...	Do
12	0—625	0·67	38·21	6·57	...	3·15	3·15	...	...	46·98	1·30	...	...	Do
13	X—463	...	CO_2=8·50	18·13	...	...	4·60	...	...	65·00	0·85	...	...	Birur, (burnt kankar).

much of the kankar used in Bangalore is said to be obtained from the Salem District (Nos. 2 and 3). Small quantities of superior kankar are obtained from Mardevanhalli and Malchakanhalli in the Mandya Taluk (Nos. 4 and 5) and are used for chunam. Other places where fairly large quantities are obtained are Honnali, Birur, Hiriyur, Hole-Narsipur and various parts of the Hunsur and Gundlupet Taluks. A large deposit was found close to the site of the Marikanave dam from which the whole of the lime required for the dam was obtained (No. 6) and at the present time large quantities are being obtained within a radius of 12 miles from the Kannambadi dam and used in its construction (Nos. 7 to 12). The analyses given in Table 25 show that the material is very variable in composition and it is improbable that the burnt kankar will contain more than about 65 per cent of lime (CaO) on the average and in many cases much less. No. 13 is an analysis of burnt kankar from Birur. The clayey and sandy impurities are not altogether useless as they serve to impart a certain amount of hydraulicity to the lime, but they increase the collection and burning charges per unit of lime. The chief defect of kankar is its great variability and though this may not be of much moment in mortar or surki-mortar used for ordinary building purposes it would be very detrimental for high class structural work, ferro-concrete or the production of a cement of any standard quality.

Cost of burnt lime.

The cost of lime burnt from kankar depends very largely on the cost of collecting and sorting the kankar and the cost of fuel. Table 26 gives the cost of kankar at various points.

The cost of casuarina charcoal at Bangalore is Rs. 30 per ton.

The cost of ordinary charcoal at Kannambadi is Rs. 30 per ton.

The cost of ordinary charcoal at Marikanave is Rs. 15-5 per ton.

The cost of ordinary charcoal chips and cowdung at Birur is about Rs. 20 per ton.

TABLE 26.—*Cost of kankar per ton.*

Locality of deposit	Cost delivered at Railway Station	Loading and rail charges to Bangalore	Unloading and carting to kilns	Total
	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
Maddur ...	1 13 4	1 12 0	0 9 4	4 2 8
Mandya ...	1 10 8	2 1 4	0 9 4	4 5 4
Morappur and Samalpatti (Salem).	1 4 0	2 3 5	0 9 2	4 0 7
Marikanave ...	...	...	...	1 4 6
Kannambadi ...	...	...	...	2 8 0
				to
				3 0 0
Birur ...	...	...	...	4 0 0

Table 27 gives the approximate costs of burnt lime per ton, but reliable figures are difficult to obtain.

TABLE 27.—*Cost of burnt lime per ton.*

	Bangalore		Marikanave	Kannambadi	Birur
	Quantity	Cost	Cost	Cost	Cost
	Tons. cwts	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
Kankar ...	1 10	6 4 6	1 7 0	3 14 0	5 0 0
Fuel ...	0 3¾	5 10 0	3 12 0	9 4 0	5 0 0
Charges for burning.	......	1 10 7	1 5 0	1 6 6	1 14 0
Upkeep of kiln	.....	0 6 8	......	......	......
Total ...	......	13 15 9	6 8 0	14 8 6	11 14 0

These figures are given for the purpose of discussing in the next section whether it is possible to replace any of this material by lime burnt from limestone. For local use and in special cases where kankar and fuel are available close at hand as at Marikanave it is not likely to be possible to furnish an equally cheap substitute. In other cases it will be largely a question of the extent of the demand and the suitability of the product for the purpose required. It must be remembered that the lime burnt from kankar is very variable and contains a large proportion of impurity and that for many purposes it would be advantageous to pay somewhat more for a uniform material richer in quick-lime.

LIMESTONE.

Distribution.

A large number of bands of limestone have been located the distribution of which is shown on the map and the composition of various specimens and samples is given in Tables 28 and 29. In referring to these the serial number of the analysis will be given in brackets. Starting from the north there are some bands running E and W to the north of Honnali of which we have no analyses.

To the north of Kumsi there are several bands of magnesian limestone which are much gashed and veined with quartz. A large amount could be obtained by sorting and dressing which would be low in silica (No. 1), but probably not so low on the average as the specimen analysed. Somewhat similar material occurs on the north spur of Shankargudda (No. 2). Near Bikonhalli, north of Shimoga, there are large masses of very siliceous magnesian limestone (No. 3) and in the schists between Channagiri and Tarikere there are many outcrops of similar material (Nos. 4 to 8). In this area the limestones are often interbanded with chlorite schist and amongst them are comparatively small patches of purer non-magnesian limestone such as that represented by (No. 9).

From here we may pass east to the western side of the Chitaldrug schist belt in which a very extensive series of limestone bands occur from the neighbourhood of the Marikanave lake and continue southwards past Huliyar, Chiknayakanhalli and Dodguni. As will be seen from the analyses these bands consist of various calcium and magnesian limestones some of which are fairly low in silica.

Further to the south we get one or two small patches of magnesian limestone at Kannambadi (Nos. 16 and 17), a large band of magnesian limestone to the west of Chettanhalli (No. 18) and another 12 miles south of Sargur—all in the Mysore District.

The origin of the limestones is doubtful. It has been suggested that many of them are not of sedimentary origin nor aqueous precipitates but due to intense calcification of trap and schist (*vide* Bulletin No. 6).

Composition and character.

The analyses given in Table 28 show the composition of various specimens collected during the course of survey work and those in Table 29 show the composition of larger samples taken in certain areas. Broadly speaking these limestones fall into two classes according to whether they contain much or little magnesia. The dividing line between these two classes is usually taken at 5 per cent of MgO in the burnt lime or from 2½ to 3 per cent in the raw limestone. Those with less than these amounts are classed as "high-calcium" and those with more as "magnesian" limes or limestones. In Mysore by far the larger part of the limestone is magnesian with about 15 per cent of MgO and varying between 10 per cent and 18 per cent and these might be classed as *Dolomite* with variable amounts of silica and other impurities. For convenience we will refer to them as dolomite and retain the word limestone for rocks containing less than about 3 per cent of MgO. From the analysis it will be seen that the two classes are fairly sharply separated and that varieties with intermediate amounts of MgO have not been found so far.

Unfortunately the two classes of rock do not appear to occur in well defined beds and do not present much difference in aspect with the result that chemical analysis is usually necessary to distinguish them.

In the Voblapur area, where a large number of samples have been collected, the two varieties occur in somewhat irregular zones or patches of considerable extent and it should be possible to obtain large quantities of either variety at will. The limestone of this area is represented by analyses 23 to 28 containing an average of about 50 per cent CaO and 7 per cent insoluble residue. Of the latter about 5 per cent is SiO_2.

The dolomite is represented by analyses 29 to 32 and the greater part of it contains less than 2 per cent insoluble residue, about 46 per cent of $CaO+MgO$ and 5 per cent $Fe_2O_3+Al_2O_3$ and should be very suitable as a furnace flux. In the southern extension of this area near Dodguni the varieties are more mixed and often siliceous and the high-calcium limestones, as represented by analyses 13 and 34, are in comparatively small patches the mining of which would be possible only for moderate quantities of high class material for special purposes.

The material from the Huliyar area (19 to 22) does not appear to be so good as that from Voblapur. The rock from the Channagiri-Tarikere schists and from Bikonhalli is mostly very siliceous dolomite (3 to 8). It is mostly fine grained with the quartz and silicates intimately distributed through the mass and some of it might possibly be suitable as a natural cement rock. This has not been tested and success seems very doubtful owing to variation in composition and to the large number of granules and veinlets of quartz which are clearly perceptible under the microscope.

In many areas the limestones are much mixed with shreds of quartz and schist and also veined with quartz and the material is practically useless as a source of lime. Some of the dolomitic bands to the north of Kumsi are much gashed or veined with quartz, but the veins are of sufficient size and definiteness to permit of being hand picked if it was found necessary to use the dolomite as a flux in that area.

On the whole the materials from the Voblapur area, which is within about 12 miles of the railway, appear to be the most promising for the production of either limestone or dolomite in large quantities.

So far as tested at present, these materials possess the

TABLE 28—*Analyses of Mysore Limestones—chiefly specimens.*

Serial No.	Registered number	Loss on ignition	Insoluble residue	Soluble SiO_2	$Fe_2O_3+Al_2O_3$	CaO	MgO	Locality	Remarks
1	S_2/770	...	1·01	...	9·36	30·49	15·09	North of Kumsi, Kumsi Sub-Taluk	
2	H_5/297	...	6·35	...	4·62	29·04	15·92	Shankargudda, Shimoga Taluk	
3	A/903	...	24·75	...	3·66	23·27	13·78	Bikanhalli, ,, ,,	
4	J_1/71	...	19·87	...	4·38	24·12	15·52	Joldhal, Channagiri ,,	
5	J_4/186	...	22·25	...	3·36	23·93	12·23	Balekal, ,, ,,	
6	J_4/212	...	17·40	...	3·32	25·12	15·60	Rangapur, Shimoga ,,	
7	J_4/230	...	15·88	...	6·20	25·46	14·11	,, ,, ,,	
8	J_3/952	...	10·27	...	5·54	27·00	15·96	Tarikere, Tarikere ,,	
9	J_4/68	...	5·19	...	2·16	48·92	2·16	4 miles E. N. E. of Joldhal, Channagiri Taluk.	

TABLE 28—*Analyses of Mysore Limestones—chiefly specimens—concld.*

Serial No.	Regis-tered number	Loss on ignition	Insoluble residue	Soluble SiO_2	Fe_2O_3+ Al_2O_3	CaO	MgO	Locality	Remarks
10	R/117	40·62	5·49	...	1·95	47·93	2·89	Huliyar area, Chiknayaikanhalli Taluk.	
11	R/956	40·05	7·72	...	1·10	49·90	1·26	Voblapur area, Gubbi Taluk	
12	R/911	44·36	2·75	...	5·10	30·00	16·44	,, ,, ,,	
13	Z_3/345	...	0·97	...	0·76	53·84	0·96	Dodguni area, ,, ,,	
14	Z_4/896	...	3·36	...	3·85	33·00	15·99	,, ,, ,,	
15	Z_4/897	...	10·78	...	4·95	27·50	16·66	,, ,, ,,	
16	...	...	2·37	0·10	4·68	32·44	15·96	Kannambadi, Mysore ,,	
17	O/678	CO_2=0·09 H_2O=6·87	4·15	0·62	7·24	51·82	29·17	,, (Burnt lime) ,, ,,	
18	J_3/671	...	5·54	...	4·08	30·20	16·21	Chattanhalli, ,, ,,	

TABLE 29—*Analyses of samples of Mysore Limestones from certain areas.*

Serial No.	Regis-tered number	Loss on ignition	Insoluble residue	Soluble SiO_2	$Fe_2O_3 + Al_2O_3$	CaO	MgO	Locality	Remarks
19	R/930	...	9·16	0·03	1·26	46·76	2·83	Huliyar area, Chiknayakanhalli Taluk, Tumkur District.	High calcium limestones.
20	R/938	...	8·89	0·04	0·94	48·10	1·35	,,	
21	R/940	...	8·67	0·02	0·94	48·16	2·11	,,	
22	R/929	...	5·76	0·02	4·88	29·64	16·51	,,	Magnesian limestone.
23	R/957	38·16	11·86	...	1·75	46·10	1·53	Voblapur area, Gubbi Taluk, Tumkur District.	High calcium limestone.
24	R/908	40·42	7·08	...	1·40	49·60	1·25	,,	
25	R/958	41·06	6·42	...	0·85	50·65	0·99	,,	
26	R/910	41·35	5·75	...	1·10	50·70	1·16	,,	
27	R/959	42·85	2·31	...	0·85	53·00	1·19	,,	
28	R/960	40·42	7·33	...	1·60	48·60	1·54	,,	

TABLE 29—*Analyses of samples of Mysore Limestones from certain areas—concld.*

Serial No.	Registered number	Loss on ignition	Insoluble residue	Soluble SiO_2	$Fe_2O_3+Al_2O_3$	CaO	MgO	Locality	Remarks
29	R/912	42·20	7·72	...	4·60	28·90	10·45	Voblapur area, Gubbi Taluk, Tumkur District.	Magnesian limestone.
30	R/914	45·26	0·72	...	5·25	31·00	16·31	,,	
31	R/961	44·55	1·99	...	5·20	30·35	14·97	,,	
32	R/962	45·76	0·70	...	5·15	31·15	15·94	,,	
33	R/895	41·16	6·27	...	2·65	47·45	3·06	Dodguni area, Gubbi Taluk, Tumkur District.	High calcium limestone.
34	R/897	43·19	1·65	...	0·55	53·77	0·90	,,	
35	R/902	...	8·87	0·02	4·00	29·00	16·90	,,	Magnesian limestone.
36	R/964	...	3·11	0·02	4·92	28·76	18·44	,,	
37	R/965	...	5·02	0·03	3·78	28·80	18·17	,,	

defect of burning to a brown colour and do not yield a white lime. This is immaterial for some purposes such as fluxing, production of surki mortar, cement, etc., but evidently bars their use for finishing purposes, chunam, whitewash, etc. The analyses show that comparatively little iron is present, especially in the high-calcium varieties, but it is probable that an appreciable quantity of manganese is present which has not been determined.

USE OF THE LIMESTONES.

Up to the present the limestones and dolomites have not been used. All the lime hitherto used has been made from kankar as already explained and it is not difficult to account for this preference. Kankar is obtainable almost anywhere in the small quantities required for local use. It can be picked up on surface or dug out from soft material to a depth of a few feet and requires no blasting or breaking and is easily burnt in small pot or trough kilns with local fuel. Limestone on the other hand is much less widely distributed; it is a hard rock requiring much blasting and breaking and unless the quarrying and burning is done on a considerable scale with trained labour the lime would undoubtedly be more expensive than that from the local kankar.

If the limestones are to be brought into use it will be necessary to ascertain that they are suitable for various purposes and that a large and steady demand can be secured permitting of the erection at some one place of the necessary kilns, plant, tram-lines, etc., and the employment of skilled supervision and labour. The following notes are merely suggestive of the possibilities which require technical investigation. There are grounds for thinking that supplies of kankar are not as abundant nor as good in quality as they have been in the past. Petty local supplies will no doubt be available for many years, but the fact that large quantities are now imported into Bangalore and the Kolar Gold Field from Salem while the supplies from Mandya have correspondingly diminished seems to point to exhaustion of the better class of local material. Again, it is stated that large quantities of lime will be required for the second stage of the Kannambadi dam and that the supply from the surrounding area is likely to prove insufficient and if this is so the kankar will have to be obtained from greater distances at an increased price. These facts are noted as suggesting that the time may not be far distant when we shall be obliged to draw upon our limestones for supplies of lime to large centres and large works and the desirability of investigating the possibilities of doing so.

Quarrying.

The quarrying of hard limestone in small quantities by inefficient local labour would probably cost Rs. 2 per ton or more. Public Works Department contract rates for excavation of granite are usually Rs. 2-8-0 to Rs. 3 per cubic yard solid and in some cases the rate is slightly under Rs. 2 for larger scale work. A cubic yard of solid limestone weighs about 2 tons so that the latter rate comes to Re. 1 per ton. In a properly organized quarry with good benches and no stripping this latter figure should be considerably improved upon and it will probably be ample to allow Re. 1 per ton for limestone broken and delivered at kilns close to the quarry. For 1 ton of burnt lime $1\frac{3}{4}$ tons of limestone will be required, or 2 tons allowing for loss, defective burning, etc. This means Rs. 2 for the limestone necessary to make 1 ton of burnt lime.

Burning.

The most suitable kiln would probably be a continuous shaft kiln using wood fuel in external grates. Some coal might be used and there is the possibility of a deficiency of wood. Firewood can be delivered at Voblapur at Rs. 6 per ton, but we will allow Rs. 7 to give a wider range. The quantity of wood required is not known exactly, but probably $\frac{1}{2}$ a ton would suffice per ton of burnt lime. The railway is about 12 miles from Voblapur and a light feeder line would be required on which the cost of transport and loading should not exceed Re. 1.

We may roughly estimate the cost of the lime delivered on the railway as follows :—

TABLE 30—*Estimate of cost of burnt lime from limestone.*

	Rs.	a.	p.
2 tons limestone at kilns	2	0	0
½ ton firewood	3	8	0
Labour and upkeep of kiln	2	0	0
Transport and loading on railway ...	1	0	0
Total per ton of lime (f. o. r.) ...	8	8	0

In some cases bagging may be necessary and this would be extra.

Comparing this with the cost of Rs. 14 for kankar lime at Bangalore or Kannambadi it should be possible to deliver the lime at those places for less than what the kankar lime costs and for much less when the relative proportions of lime (CaO) are taken into account. That burnt from kankar will probably average not more than 65% of lime while that from the limestone will average about 86% including magnesia. One ton of the latter should therefore be worth 1⅓ tons of the former if equally suitable in other respects. Lime sells in Bangalore for about Rs. 18 per ton and 1⅓ tons will cost Rs. 24 and the difference between this figure and the Rs. 8-8-0 obtained above should leave a fair margin of profit after paying for supervision, taxes, transport and sale. Whether the figures given prove to be very accurate or not the project appears to be worth serious investigation. The fact that the lime is brown will preclude its use for several purposes, but for ordinary building purposes, preparation of surki mortar, etc., there should be a considerable demand amounting to several thousand tons a year. For the second stage of the Kannambadi dam some 48,000 tons of kankar will be required and it will probably be more difficult and expensive to supply this from kankar obtainable in the neighbourhood than is the case at present when the lime costs about Rs. 14 per ton as shown above under the head of "Kankar."

Hydrated lime.

Hydrated lime is lime which has been carefully slaked and sieved at the works and does not require further slaking by the consumer but merely mixing with water. It has the advantage that it can be stored for a considerable time without much deterioration and that the erratic and uncertain slaking usually performed at the building site is avoided.

Lime for paper pulp.

The manufacture of paper pulp at Shimoga is under investigation and if it is undertaken there will be a steady demand for some 3,000 tons of burnt lime per annum. This would give additional work and reduce standing charges.

Cement.

In considering further outlets for the products of the limestone quarries we may briefly refer to the production of cements. We have not found a natural-cement rock near Voblapur. Some of the siliceous limestones from the Tarikere area might produce a natural cement—though we are doubtful about it—but that would be of no use for a works at Voblapur where the object should be to concentrate as much quarrying, burning and crushing work as possible in order to secure a sufficient total volume of business to bring the standing charges down to within reasonable limits. There is not enough demand in Mysore in any one line to justify the erection of an economical plant and the employment of high class supervision, labour and machinery and hence the need for endeavouring to concentrate several lines of work in one place. For this reason it would probably be impossible to run a commercially successful plant for making natural cement near Tarikere even if the rock is found to be suitable and as already stated we do not know at present of any likely rock near Voblapur.

As regards Portland Cement no doubt the high calcium limestones of Voblapur could be used and some experiments might be made with the dolomites though, for reasons with which we are not acquainted, the presence of more than 3 or 4 per cent of MgO is invariably barred in a Portland Cement specification. In addition to the limestone a suitable clay or shale is required and the presence of a suitable supply has not been investigated yet. As this Bulletin is meant to be suggestive we may briefly consider the possibilities, but we hesitate to say much about such a technical and highly specialized process as the production of a high class Portland Cement. The consumption in Mysore is small. We have not got figures but probably it does not exceed a few hundred tons a year and there is little chance for export. No doubt its use will increase and we may make a rough estimate for an output of 5,000 a year for the sake of argument.

TABLE 31—*Estimate of cost of Portland Cement.*

	Rs.	a.	p.
$1\frac{1}{5}$ tons limestone at Re. 1	1	4	0
$\frac{1}{3}$ ton dry clay at Rs. 1-8-0 (?)	0	8	0
Power for grinding raw materials and clinker, using coal at Rs. 22 per ton	12	0	0
Powdered coal for rotary kiln	8	0	0
Labour	2	8	0
Supplies, repairs, etc.	4	0	0
Supervision, laboratory, office, etc. ...	3	8	0
Depreciation 10% on $2\frac{1}{2}$ lakhs	5	0	0
Interest 5%	2	8	0
Cost of bags or barrels	5	0	0
Total per ton packed ...	44	4	0

Imported cement costs about Rs. 10 per barrel or, say, Rs. 60 per ton in Bangalore and even assuming that the quality of the Mysore cement compared well with that of the imported article there is little margin for transport, sales and profit. At present the consumption is only a fraction of 5,000 tons a year and for such smaller amount the costs per ton would go up considerably. On the other hand if the demand goes up to any thing like the 5,000 tons on which the estimate has been based there are various reductions which might be suggested. The most important of these is in the power required for grinding, etc., for which electricity might be substituted for coal. If electric power could be supplied at 0·5 anna per unit the cost of power should come down to half or less, a saving of 6 or 7 rupees per ton, and if the work is done in conjunction with burning and crushing of limestone for other purposes the charges for staff, depreciation, etc., could be partly allotted to this other work making a further reduction of a few rupees per ton. We might thus expect to reduce costs to Rs. 34 or 35 per ton as compared with Rs. 60 for the imported article and if the cement was good enough to sell at Rs. 50 to 60, profitable work should be possible. Cement making is a delicate and tricky operation, but we have shown reasonable grounds for a further investigation by experts.

Limestone for flux.

In connection with the iron smelting scheme previously referred to there would be a demand for some 5,000 tons of limestone per annum. For this purpose low silica is most essential and as the presence of magnesia is not a serious detriment some of the dolomite from Voblapur could be used, as it is much lower in silica than the limestone. It should be possible to deliver the rock at Shimoga for about Rs. 5 per ton if low freights are obtained, say $\frac{1}{5}$th or $\frac{1}{10}$th of a pie per maund per mile.

Crushed limestone.

Many of the soils of Mysore are deficient in lime and it is worth while considering whether the lime needed to make good this deficiency can be supplied at a sufficiently low price to prove attractive. Dr. Coleman, Director of Agriculture, has furnished us with information as to what has been done in this direction elsewhere and has undertaken to have experimental tests made with both limestone and dolomite, both burnt and finely ground, and for this purpose about 20 tons of rock have been obtained and suitably prepared. There is still much difference of opinion as to the relative values of burnt lime and ground limestone and also as to the effect of the presence of magnesia, but there is a considerable amount of experimental evidence tending to show that magnesia is not detrimental and may replace an equivalent quantity of lime and further that the raw ground limestone is as useful as burnt lime though slower in action. A greater weight of the limestone must be used to furnish the same quantity of lime—roughly about twice as much—and it is still uncertain whether these proportions will afford equivalent results. It does not appear necessary for the limestone to be very finely ground and it is probably sufficient for it to pass through a 12 or 14 mesh in which case much of the product will be very much finer. The finer portion will be acted upon comparatively quickly by the acids in the soil and the coarser portions will come into use in the course of a few years. Assuming that the crushed limestone proves successful and that 2 tons are required per acre every five years we may consider the probable demand. Many of the coffee estates require lime and some have purchased burnt lime at a cost of Rs. 30 per ton at Birur. If the lime was cheaper much more would be used. There are 100,000 acres of coffee and if owners of one-fourth of the area were prepared to pay for lime at the rate of 2 tons of limestone per acre every five years we should have a demand for 10,000 tons of crushed limestone per year. The demand would probably tend to increase, and there might be a considerable demand in the case of other high class crops also, so that we might expect a demand of 10,000 tons and upwards for crushed limestone which would be a considerable addition to the lime business and help to reduce standing charges in quarrying, crushing, working of tramway, etc. If we allow Re. 1 for quarrying, Rs. 2 for crushing and Rs. 2 for transport the cost at Birur would be Rs. 5 per ton and its value should be several rupees more which would cover other charges, profit, etc. It seems probable that 2 tons of the crushed limestone would be cheaper than 1 ton of burnt lime and considerably cheaper than any form of lime at present obtainable.

CONCLUSION.

We have shown that large quantities of fairly good limestone and dolomite occur in the neighbourhood of Voblapur in the Tumkur District not far from the railway.

Hitherto no limestone has been used in the State and we have suggested various lines and schemes which if successful would create a demand for some 20,000 or more tons of limestone per annum and this with the necessary burning, crushing and other treatment suggests the possibility of an industry on a sufficient scale to pay for the employment of the necessary supervision and plant on up-to-date lines and to yield a fair margin of profit. The proposition appears, at any rate, to warrant expert technical investigation.

CLAYS.

Clays may be described as earthy materials which become plastic when wetted. They are formed by the alteration or decomposition of rocks and consist of the residual products of such decomposition. They are called *residual* clays when they remain *in situ* on or in the rocks from which they have been formed and *transported* clays when formed by the denudation and removal of these decomposition products by water and their subsequent deposition in sedimentary or alluvial layers. In some cases the deposits may be wind borne.

The base of most clays consists of hydrous silicates of alumina of which the most important is the mineral kaolinite. The character of the clay depends on the proportion of other ingredients or impurities such as sand, various silicates and oxide of iron. There are few, if any, noteworthy deposits of clay in Mysore, but common clays suitable for the manufacture of bricks and sometimes tiles are widely distributed in the flood plains along the river courses and in the numerous tank beds situated along shallow valleys. These deposits are usually very mixed, layers of plastic clay alternating with layers of sand and loam, and extensive beds of high grade plastic clay are rare.

Ordinary bricks can be made almost anywhere and the class of product obtained is largely a question of the selection and treatment of the clay and the care taken in moulding and burning. In most places cheapness is the great consideration rather than finish or durability and it is doubtful if the majority of bricks now made are as good as those made in former years and certainly not as good as the old hand-made bricks to be found in old forts and buildings.

Ordinary hand-made bricks, sun-dried, are sold for Rs. 1-8-0 to Rs. 2 per thousand. If burnt, they cost from Rs. 4-8-0 to Rs. 5 per thousand.

Very good pressed bricks can be made at about Rs. 10 per thousand and the development of this class of work might be encouraged. The difficulty is to persuade people to pay the extra price for the more durable article when the common burnt brick is available and serves the purpose sufficiently well for the time. There is a demand for higher class bricks in the larger towns and wire cut bricks are supplied by the Bangalore City Brick & Tile Works for about Rs. 18 per thousand. Clays suitable for tiles are found in many places and are used by local workers for the production of flat and pot tiles, chatties, etc. In recent years there has been an increasing demand for tiles of the "Mangalore" pattern which require a good deal more skill and plant for their manufacture and in which a large and steady output would appear to be one of the chief factors for success. Works for making this class of tile have been put up at Bangalore, Mysore, Saklespur, Harrihalli, Sringeri and Sagar, but with the exception of the first they do not appear to have met with much success and are reported to require remodelling on more modern lines. A new factory is stated to be in course of erection at Tirthahalli in which the kilns and plant will be of an up-to-date type and if commercially successful others may follow.

KAOLIN.

Kaolin or China-clay is a name applied to white-burning, slightly plastic, clays of a very finely pulverulent texture, which are generally considered to be largely composed of the mineral Kaolinite—a hydrous silicate of alumina.

It is most usually derived from the decomposition of the felspars of granites and pegmatites and is found as part of the decomposed rock mass in admixture with quartz, mica and other silicates which have not been decomposed or removed. For this reason, it is necessary to wash the decomposed mass so as to separate the very fine kaolin from the coarser mineral grains and the term kaolin is usually restricted to the fine white clay so prepared. More rarely white clays and lithomarges are found in beds or masses in a sufficiently fine or pure state to be dug out and used for pottery work and these are sometimes included in the term kaolin. The decomposition of the felspars and the production of kaolin is a widespread result of weathering in which water and carbonic acid play the most important parts. In order that a deposit of kaolinized material should be formed, it is necessary not only that the rock should be very highly decomposed but that the soft decomposed material should be protected from denudation. In Mysore we have cases of highly decomposed pegmatite veins containing kaolin and protected from denudation by the harder enclosing gneiss or granite and there are many cases of such veins or of white bands of the granite or gneiss which are highly decomposed and protected by an overlying layer of laterite or hard laterite soil.

The depth to which the kaolinized material may be expected to extend is determined by the depth of extreme decomposition and will average to some 30 to 50 feet from surface. Below this point the rock begins to get harder and much of the felspar is undecomposed so that the amount of kaolin obtainable on washing will diminish rapidly and the resulting product will probably be less fine and soft.

In the great kaolin areas of Cornwall in England the conditions are very different. There, large masses of white decomposed granite are found in which intense decomposition extends downwards for some hundreds of feet with the production of exceptionally fine white kaolin throughout the mass. These decomposed masses are often of considerable lateral extent and individual pits have an area of many acres. Many authorities consider that kaolinization in Cornwall is due to the action of deep seated igneous vapours and is not due primarily to mere surface weathering so that in mode of origin as well as in extent and purity the kaolin deposits of Cornwall are very different from those of Mysore.

Distribution.

Kaolinized granite and gneiss occurs abundantly in several parts of Mysore beneath the laterite caps and the stiff laterite soils derived from them or from various more or less lateritic materials. These masses are very variable in colour and are usually yellow, pink or red and it is only rarely that bands or veins are found which are sufficiently white to yield anything which could be classed as kaolin. The whiter bands and veins so far discovered are of small lateral extent and from what has already been said they cannot have any considerable extension in depth. Some of these might yield from a few hundred to a few thousand tons of kaolin, but none of them would appear to be sufficiently extensive to justify the erection of an up-to-date washing plant or the provision of any special transport facilities to a railway, and in most cases they are far removed from existing lines.

Samples of kaolin have been obtained from the following localities and remarks are added as to their characters.

Mysore District.—On the Melkote hill there are two or three small deposits of decomposed gneiss from which sticks of kaolin are prepared for making caste-marks. The material contains from 10½ to 14 per cent of levigated kaolin which is fairly white, but burns buff colour.

Bangalore District.—At Golhalli the decomposed gneiss in a nulla contains some decomposed pegmatite veins from which 25 to 30 per cent of white kaolin can be obtained which burns white. The quality is said to be good, but the quantity is not large—probably inside of 1,000 tons. Outcropping veins are contaminated with iron, but a good vein, a few feet thick, was found at a depth of 15 feet. Mining of any considerable quantity would be difficult owing to the tendency for pits and shafts to close up during the rains.

Near Hindiganal in the Hoskote Taluk kaolin occurs in decomposed gneiss beneath the laterite. Most of it is slightly yellow or pink and is not favourably reported on.

Kadur District.—Samples of fairly white kaolin have been obtained from a number of places, but on further examination the quantities available were found to be too small to be worth further attention. In the following three places somewhat larger quantities occur:—

At Asgod in the Koppa Taluk there is a considerable quantity of decomposed gneiss beneath a few feet of soil from which possibly a couple of thousand tons of kaolin could be extracted. The colour is however distinctly yellowish and this will probably debar its use for most purposes.

At Kokkod in the same taluk a deposit has been found which yields about 22 per cent of white kaolin. The quality seems fairly good and if wanted it is probable that one or two thousand tons might be obtained and possibly more in the neighbourhood.

At Kikri in the Sringeri Jaghir a pegmatite vein, about 12 feet wide and a furlong or more in length, yielded some 23 per cent of white kaolin which however contains a good deal of fine mica which is difficult to separate by levigation in tubs. Probably one or two thousand tons could be obtained.

Chitaldrug District.—Some occurrences of greyish white to purple materials have been noted near Bhimasandra and Marikanave, which might be classed as lithomarge, and would probably not be valued as kaolin on account of bad colour.

It will be seen that in no case has anything of the nature of a large deposit been found which would justify the erection of a modern plant or one in which working expenses would be low. Several tons of material have been excavated departmentally and levigated in tubs and a number of bags of prepared kaolin have been sent to Bombay to ascertain values.

A large amount of English kaolin is used in Bombay for cotton sizing and is valued at some Rs. 50 per ton in normal times. Local supplies of kaolin are now being sold in Bombay at this figure, or over, owing to war freights, but it is reported that they found a market with difficulty before the war.

Under these circumstances, it is doubtful if supplies could be sent from Mysore to Bombay at a profit in view of their distance from a railway and the long railway lead to Bombay. Enquiries are being made on these points.

Some time ago it was suggested that a porcelain factory should be started in the State and doubtless our small deposits of kaolin would prove useful for some classes of porcelain or pottery ware. It must be remembered however that for the manufacture of such wares many other ingredients are required besides kaolin and Mr. Fern of the School of Arts, Bombay, has reported that it would not be possible to manufacture white earthenware or soft paste porcelain owing to the absence of plastic or ball clays which burn white. He states that hard paste porcelain might be made but that highly skilled labour is required. A valuable account of the occurrence, mining and preparation of Kaolin will be found in " A handbook to the collection of kaolin, China clay and China stone in the Museum of Practical Geology, Jermyn St., London, S. W." by J. Allen Howe, B.Sc., F.G.S.

FELSPAR.

Felspar is used in the pottery industry for the manufacture of certain varieties of porcelain and for the preparation of glazes. So far there has been no demand for it in Mysore but, if required, it could be obtained in many places from the coarser grained pegmatites in which the crystals are sufficiently large to permit of being hand picked from the associated quartz. Both white and pink felspars occur, most of which are soda felspars, but some potash felspars (orthoclase and microcline) have also been noted. Little attention has been paid to the mineral owing to the absence of any demand for it.

A number of samples have been collected from time to time and some from the mica pits near Vadesamudra have been reported to be suitable for glazes and other pottery purposes.

BUILDING AND ORNAMENTAL STONES.

Many parts of the State are well supplied with building stones which can be obtained from the surface exposures of granite and gneiss many of which are remarkably fresh.

The gneiss, some of which is highly streaked or banded and some of which is a fine uniform grey granite, is usually quarried by fire-splitting, whereby successive layers of a few inches in thickness are separated from the mass below by the action of a fire built on the surface and slowly moved across it.

The loosened layers are split into slabs 2 feet wide and 10 to 15 feet long by wedging. The slabs may run up to 6 or 8 inches in thickness and thicker blocks are obtained by the blasting and wedging of thicker layers separated by natural joint planes.

A number of red granites or grey granites with reddish felspars occur in several places and are used locally. Amongst these may be mentioned the granites of the Closepet range, the Arsikere and Banavar massifs and that of Chamundi.

The potstones of the Hassan and Mysore Districts have been largely used in old temples especially where intricate carving is required.

The Turuvekere trap, a dark and rather soft amphibolite passing in places into potstone, has been used in several cases for ornamental work and takes a fine black polish.

A varied series of porphyry and felsite dykes occur in the Seringapatam, Mandya and Mysore taluks of which a number have been used as ornamental stones in the new Palace at Mysore.

A green quartzite or gneiss containing the chromium mica *fuchsite* occurs in several places and has been used sometimes for inlaid work. The best variety comes from Belvadi in the Kadur District.

The more ornamental stones are, however, rarely used owing to their greater cost and difficulty of extraction in comparison with the commoner forms of grey granite and gneiss. Suggestions have been put forward from time to time for the quarrying and dressing of some of these with a view to export, but no practical scheme of a profitable aspect has yet been put forward.

A description of many of the porphyry and felsite dykes will be found in the Appendix to Vol. VII of the Records of the Department and a large variety of polished samples of the principal building stones of the State can be seen in the museum of the Department of Mines and Geology, Bangalore, and information obtained as to their location, mode of occurrence, etc.

IV. Rare Minerals.

A few minerals containing some of the rarer elements have been found in Mysore and though they are too scarce to be of economic importance they may be referred to briefly, in view of the fact that they are often the subject of attention and enquiry.

Monazite.

Monazite occurs sparingly in crystals or grains in certain gneisses and pegmatites. The mineral is yellow to red in colour and is essentially a phosphate containing cerium and thorium and other rare metals. Its value depends chiefly on the amount of thorium present, the oxide of which is used in the preparation of incandescent gas mantles.

In the sands derived from these rocks it may become more abundant and where these sands are subjected to the sorting action of waves on the sea-shore the degree of concentration may become considerable and valuable deposits may be formed, such as those discovered in recent years on the Travancore coast.

In Mysore, there has been little concentration and no deposits of any value have been found.

A few handfuls of monazite crystals have been obtained from decomposed pegmatite near the 5th mile on the Bangalore-Kankanhalli road. The quantity available is small and the amount of thoria in the mineral is only some 2¼% which compares very unfavourably with the monazite from Travancore, which is reported to contain from 6 to 10%.

On the west side of Kolar schists—near the Bowringpet Road—Mr. Louis Stromeyer found a number of pieces of a quartzose gneiss containing specks of a reddish mineral which on being tested proved to be monazite or some allied mineral. No notable quantity of either the rock or mineral has however been located.

Some licenses have been taken out in the Kadur and Hassan Districts and a large number of washings made of the stream sands some of which were stated to contain thorium. No analyses have been furnished, but a large number of the concentrates from the sands, which were examined, failed to show any appreciable quantity of monazite.

A large number of river washings have been made from time to time by officers of the Department—chiefly in the neighbourhood of the charnockites of the Mysore District—and occasionally a few grains of monazite have been detected, but nothing of any particular value.

Samarskite.

A number of small pieces and plates of what appears to be Samarskite were found associated with the monazite in the decomposed pegmatite near Bangalore.

Columbite.

Crystals and lumps of columbite are sometimes found in the pegmatites of Mysore especially in the mica pits. The mineral is nearly black with sub-metallic lustre and is composed of niobate and tantalate of iron and manganese.

Several hundred pounds were collected by licensees from pits near Yelwal and Tagadur in the Mysore District and reported as tantalite. The distinction between tantalite and columbite depends on the proportion of tantalic acid present and a sample from Tagadur was found to contain only 1·14%. It therefore belongs to the variety columbite and is of no value.

Beryl.

Crystals of pale-green beryl have been found in a quartz vein near the Kempambudi Tank, Bangalore, and some crystals of a yellowish colour in a cutting on the road leading to Melkote in a pegmatite. In both cases the mineral is much fissured and poor in colour and has no value as a gem stone.

Graphite. Graphite, one of the crystallised forms of carbon, though not a rare mineral, may be included here as it occurs only in very limited quantities. It has been found in several places but nowhere in sufficient abundance to be of commercial value. It occurs occasionally in gneiss and particularly in some of the gneisses of the Mysore District. Near Bangalore it has been found as micaceous looking spangles in a white quartzite or fine grained quartz vein in gneiss. A concentration test of this showed about ½% of graphite in the rock. It occurs associated with some of the auriferous quartz of the Kolar Field in some workings from Trial shaft, Nundydrug, on what is supposed to be a continuation of the Oriental Lode. In this case the selvage edges of the vein and some of the joints or cracks along which movement has taken place are freely coated with graphite. To the north of the Kolar Field some fine grained graphite schist occurs near the old working at Manighatta and somewhat similar material has been found in the Chitaldrug schists and amongst the chloritic and hornblendic schists on the scarp of the Bababudans near Hoskan. In the last instance, the schists appears to consist of fine grained chlorite or talc with finely divided quartz and iron ore, the whole being penetrated by short lenses and veins of white quartz on the edges of which the graphite is somewhat concentrated. As the schist was quite black and marked paper readily, an attempt was made to separate the graphite which is in the form of very fine dust or particles. By levigation an impalpable powder was obtained containing practically all the graphite which was present to the extent of 6½%. The amount of graphite in the rock as a whole would be about 3%. The levigated powder is so fine that it would probably be impossible to further concentrate the graphite from it and the powder itself does not appear to be of any use or value except possibly as a dark pigment.

Bangalore,
29th May 1916.

DEPARTMENT OF MINES & GEOLOGY

MYSORE STATE

LIST OF PUBLICATIONS

RECORDS OF THE MYSORE GEOLOGICAL DEPARTMENT.

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VOL. I, 1894 TO 1897.

Part 1.—General Report from 1st October 1894 to 31st December 1895. Preliminary report on the Iron Ores in the neighbourhood of Malvalli. Notes on the Corundum deposits in the south of Mysore. Notes on prospecting work for minerals in Kadur and Mysore Districts. Notes on the Marikanave Gorge.

Part 2.—Annual Report for 1896. An Account of prospecting work in Mysore, Hassan and Tumkur Districts. Suitabilities of 'Talpargi' springs for the water-supply of Tumkur. Report of the Inspector of Mines in Mysore for 1896, with mortality tables.

Part 3.—Annual Report for 1897. Notes on the Mysore Decorative and Building stones. The porphyry dykes in Seringapatam, T.-Narsipur and Mandya Taluks. Note on Ruby Corundum from Sringeri. Report of Prospecting work in 1897. Notes on the Honnegudda and Hiriyur Mining blocks, Shimoga District. Report on the Geology of the Kotemaradi block, Chitaldrug District. Notes on the Ajjampur Mining Block, Kadur District. Report of the Chief Inspector of Mines in Mysore for 1897.

VOL. II, 1898 AND 1899.

Part 1.—General Report for 1898 and 1899.

Part 2.—Reports on old workings near Tarikere and Nandi with map. Notes on Geological work in the Gundlupet Taluk. The distribution of laterite in the Kolar District. Geology of the Chitaldrug and Tumkur Districts with map. Report on prospecting work in parts of Chitaldrug and Tumkur Districts. Preliminary report on geological work in the Shimoga, Honnali and Shikarpur Taluks, with map. Geological notes in the Hassan District. Notes on a tour across the State from the Kolar District to the Jog falls. Reports on the site for the Marikanave Dam with map. Reports on the samples of water from Marikanave with Analyses.

VOL. III, 1900 AND 1901.

Part 1.—General Report for 1900 and 1901. Short review of geological work in the Kolar, Tumkur, Mysore and Chitaldrug Districts.

Part 2.—Report on the geology of the Country between Kibbanhalli and Seringapatam with map. Traverse notes between Nittur and Kunigal. Petrological notes on altered ultrabasic dykes near Turuvekere. Limestone concretions in Nanjangud Taluk. Geology of Hosdurga and Hiriyur Taluks (second notice) with map and section. Notes on the Country to the west of the Kolar Schist belt. Traverse notes in the Kolar, Bangalore and Mysore Districts. Economic Mineral Products.

VOL. IV, 1902-03.

(*Out of Print.*)

Part 1.—General report for 1902-03. Miscellaneous Notes. Ajjampur and Tarikere areas; Honnali and Channagiri Taluks.

Part 2.—Preliminary report on parts of Tumkur, Bangalore and Kolar Districts with a map. Anantapur Schist belt. Traverse notes from Dharmavaram to Hiriyur. Petrological description of rocks from Tarur hill, Sira Taluk. Geology of Ajjampur and Tarikere with a map. Note on Gedrite bearing rock from Palwalli, Pavagada Taluk. The Lal-Bagh gneissic quarry, Bangalore. Preliminary report on country between Shikarpur, Davangere and Holalkere in the Shimoga and Chitaldrug Districts with map and sections. Notes on Magnesite, Mysore District. Asbestos near Bangalore. Occurrence of manganese ore near Madadkere, Hosdurga Taluk. Economic mineral products in Kadur and Hassan Districts.

VOL. V, 1903-04.

Part 1. General report for 1903-04. Inspection notes of the State Geologist on the Kolar Schists, the Biligiri Rangan hills, the Bellara and the Bodimaradi gold mines, and on the Javanhalli and Chitaldrug Schist belts. Notes on Sakrebail, Shankargudda and Kumsi areas. Traverse notes between Kallurkatte and Kodachadri, Shimoga District.

Part 2.—Report on the Eastern portion of the Chitaldrug schist belt lying between Aimangala and Nittur. The Javanhalli Schist belt with a map. A Preliminary geological report on parts of Shimoga and Kadur Districts comprising Kodachadri, Agumbe, Lakvalli and Shankargudda areas with a map. Asbestos occurrences. Mica at Hardur and at Chikkanhalli. Old workings for gold in Hole-Narsipur and Channarayapatna Taluks. Pyrites, apatite and other mineral occurrences.

VOL. VI, 1904-05.

Part 1. General report for 1904-05.

Part 2.—Geology of parts of Tarikere, Channagiri and Shimoga Taluks with a map. Gangur and Ubrani iron ores. Mineral resources of Mysore and Kadur Districts. Summary of geological work in Mysore and Tumkur Districts. Malvalli iron ores (second notice). Traverse notes in Nagamangala, Attikuppa and Hunsur Taluks. Geology of Chitaldrug District with map and sections.

VOL. VII, 1905-06.

Part 1.—General report for 1905-06.

Part 2.—Geology of Shimoga, Tarikere, and Kadur Taluks with map. Kaldurga conglomerates; Lakvalli and Nandi old workings for gold. Felsite and Porphyry dykes round Seringapatam with a map and Appendix. Geology of Hassan and Tumkur Districts with a map. Bommanhalli and Nuggihalli Schists. Traverse notes in Srinivaspur and Kadri Taluks. Report on the Geology of Challakere and Sira Taluks with map.

VOL. VIII, 1906-07.

Part 1.—General report for 1906-07. Short notes of a traverse from Banavar to Bhund Ghat. Review of the Geological work in the area south of the Kabbani river, and in the Sorab and Shikarpur Taluks. Iron ores near Sivasamudram.

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VOL. X, 1908-09.

Part 1.—General report for 1908-09. Geological notes on Bangalore gneiss. Malvalli and Bababudan Iron ores and the possibility of making use of them in iron smelting. Water resources of the State.

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VOL. XI, 1909-10.

Part 1.—General report for 1909-10. Inspection notes and comments on the Mallappanhalli conglomerate, Talvati rock, Jogimaradi trap, G. R. formation and Aimangala conglomeretes in Chitaldrug District. Sequence of rocks in the Chitaldrug Schist belt. The Shimoga granite, Kallurkatte gneiss and white mica schists, Shimoga District. Traverse notes from Sringeri to Gangamula. Note on the relations of gneiss, granite and schist at Nelligere, Tumkur District. Laterite in Mysore. The fundamental gneiss of Mysore.

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VOL. XII, 1910-11 AND 1911-12.

Part 1.—General report for 1910-11. Review of mineral production during the year.

General report for 1911-12. Review of mineral production. Resume of survey work done during the year. Notes on Economic minerals.

Part 2.—Geology of Holalkere, Davangere and Channagiri Taluks with map and sections. Geology of the Kudremukha and Gangamula regions, Kadur District, with map and sections. Report on a portion of the Closepet granite and associated rocks with map. Geology of parts of Bangalore and Tumkur Districts. Geology of Krishnarajpete, Yedatore and Nagamangala Taluks, Mysore District, and of Channarayapatna Taluk, Hassan District. Geological notes in the vicinity of Kannambadi reservoir dam. Inspection notes on prospecting blocks in the Province.

VOL. XIII, 1912-13.

Part 1.—General report for 1912-13. Obituary notice of Mr. H. K. Slater. Inspection notes on mining blocks and on survey work. Water-supply and bore hole experiments. Talpargis. Review of mineral production during the year.

Part 2.—Preliminary geological report on the south-west corner of Mysore District with map and sketches. Talpargis in the Maddagiri sub-division with plans and sections. Notes on the geology of Nelamangala and Dodballapur Taluks. Conglomeratic quartzites near Chikmagalur. Note on the clay deposit at Tinnalu, Bangalore Taluk, with plan and sections. Report on the Woolgiri block (Nanjangud Mine) with plan and section. List of Assays of Nanjangud samples. Report on the Nanjangud gold mine.

The price of the Records is Two Rupees per Volume.

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Map of the Kolar Schist Belt—Plate I.

Map of the Kolar Gold Field—Plate II.

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