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INDIA'S MINERAL WEALTH

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VOL. IV

INDIA'S MINERAL
WEALTH.

INDIA OF TO-DAY

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INDIA OF TO-DAY

VOLUME IV

INDIA'S MINERAL WEALTH

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INTRODUCTION

No attempt is made in the following pages to review in detail the development of the indigenous mineral industries of India from ancient times, onward through the mediæval period up to the present day, or to analyse the causes which have brought about the extinction of once flourishing mining and metallurgical enterprises. These are matters of historical interest which possess no title to a place in a short conspectus of this kind. The large stores of useful knowledge in our possession now, scattered though they are through a bewildering number of publications, are comparatively recent acquisitions coeval with the geological survey of the country by State and private agencies. The Geological Survey of India had its beginning in the desire of Government to have the coalfields systematically investigated, and it was only after the principal ones had been mapped and described that the routine survey was taken up, and with it not only the examination of such mineral deposits as were met with, but the colligation of all the isolated observations relating to them. Up to the early eighties practically nothing had been done in the experimental development of Indian minerals, and without this, it is impossible to form any accurate judgment of their modes of occurrence, or of their potentialities. Thus the author of the pioneer work on Indian economic geology which was published in 1881 wrote as follows,—"Hitherto mining for metallic ores by British companies has not been successful in this country, though coal and salt mining and the quarrying of building materials have been carried on by the Government or by private companies, with in many cases very great profit. It would seem however, that, as regards the metals there is a new era about to commence, and that the capabilities of India, not only as a gold-producing country, but also in reference to other metals, will in the course of the next few years be for the first time fairly tested." Valentine Ball read the signs of his times correctly, for the developments of the next decade or two fully justified the truth of his prediction. Mineral deposits of many kinds were discovered and opened up; the ancient platitude that they were as a rule too poor to support large scale treatment, died a natural death, and although for a time exploitation resulted mainly in the export of raw products to other countries, the manifold advantages to be gained by dealing with them here were at length realised, and India is now taking her proper place amongst the metallurgical nations of the world.

By 1899 the growth of prospecting operations necessitated the issue by Government, in that year, of Rules to govern the grant of Prospecting Licenses and Mining Leases, and the number of concessions taken up over lands in which the mineral rights have been retained by the State rapidly increased, as the following table shows.

NUMBER OF MINERAL CONCESSIONS GRANTED.

Year	Number
1899	60
1904	151
1909	692
1914	363
1919	708
1922	651

To register the progress of the Mineral Industry, a Review of the Mineral Production of India was issued annually by the Reporter on Economic Products for the four years 1894 to 1897, but in 1898 it was decided, owing to the want of uniformity in the rate of development of many minerals, to publish reviews of progress at wider intervals, covering periods long enough to permit of the determination of any secular variations. The first of these reviews, dealing with the six years 1898 to 1903, appeared in the Records of the Geological Survey of India in 1905, and since then, quinquennial reviews have been forthcoming regularly. In addition to these, a brief annual statement of the quantity and value of all the important minerals raised, has appeared each year in the Records since 1906.

Apart from the papers on mineral deposits scattered through the fifty-five volumes of the Records of the Geological Survey of India, and the special monographs dealing with subjects such as coal, petroleum, mica, gold, manganese, bauxite,

etc., which have been published from time to time as Memoirs of the same Department, there exists a vast and growing literature on all branches of Indian geology, which has been assembled and made easily accessible through the untiring industry of T. H. D. La Touche. His "Bibliography of Indian Geology and Physical Geography", published by the Government of India in 1917, contains the titles of the papers of no less than 1,989 authors, and each one of these, with very few exceptions, was personally verified by the compiler. In Part II, issued in 1918, Mr. La Touche has furnished a guide to the literature on Indian minerals of economic importance, and, at the same time, has indicated in a brief manner the nature of the information given by each observer. In 1921, an index of localities followed and a subject index is now in the Press. The bibliography is kept up to date by the issue, year after year, of a list of the various writings published during the period, dealing in any way with the subject of Indian geology and affiliated subjects, of an appendix to the annual report of the Geological Survey of India. Mr. La Touche's books are indispensable to students of Indian mineral deposits, and the labour that they save the enquirer is best appreciated by those who have lost themselves in the maze of the literature with which they deal, before their assistance was available.

In 1908, a short account entitled "A Sketch of the Mineral Resources of India", by Sir T. H. Holland, was published and the present booklet is written on much the the same lines. It aims at presenting the main facts known about each mineral in as condensed and popular a form as possible. Since 1908 there have been so many changes that an account written then is more or less obsolete now. Sir Thomas Holland found it necessary to deal with 54 distinct minerals, to day we are compelled to include 77 in the list. In 1908, the total value of minerals raised for which returns of production were obtainable, was roughly £7,800,000; in 1920, the value was over £30,000,000. Since that time, more coalfields have been tapped by railways and fresh oil-fields drilled; the enormous iron ore resources of Orissa have been partially proved, while a successful iron and steel industry with its attendant subsidiaries has been established; the copper-bearing lodes of Singhbhum have been explored and the production of refined copper commenced; the great reserves of argentiferous lead-zinc sulphides of the Northern Shan States, have made Burma the chief new factor in the world's production of lead; the wolfram deposits of Lower Burma, then practically untouched, are now known to be the most important in the British Empire, and supplied the needs of the Allies for the greater part of the war period; the monazite deposits of Travancore, then absolutely unknown, have proved to be the largest and richest in the world. India still heads the list of the world's mica producers, while her deposits of manganese ore have given her the same proud position as regards that mineral from time to time. India now produces gold, silver, lead, copper, iron and steel; petroleum is refined and cement made on a large scale within her borders; her manganese ores are smelted to a degree sufficient to meet the requirements of her iron industry, and a commencement has been made in the by-product coking of her coals. The next decade may witness a great expansion of these industries; it may see the inauguration of aluminium, zinc and tin extraction, the production of ferro-alloys, carbide of calcium and artificial abrasives in the electric furnace; the manufacture of sulphuric acid, glass and porcelain on a really large scale from indigenous materials.

In considering the growth of the realisation of the mineral wealth of any country it is essential to take a long view, so that the minor irregularities of the trend, in whatever direction it may be, are smoothed out, and the gaps caused by temporary disturbances are bridged over. With this object in view the figures given in the following table have been collected.

TABLE I

Average annual value of certain Indian Minerals produced during the periods

1898–1903, 1904–1908, 1909–1913, 1914–1918.

—	1898–1903	1904–1908	1909–1913	1914–1918
	£	£	£	£
Amber	362	648	182	280
Chromite	...	9,110	4,282	20,164
Coal	1,225,677	2,139,249	2,969,305	4,419,174
Copper Ore	...	...	...	12,418
Diamonds	...	2,799	872	1,216
Gold	1,904,719	2,266,307	2,241,844	2,258,653
Graphite	11,981	12,879	16,363	641
Iron Ore...	13,584	13,769	29,519	34,819
Jadeite (*a*)	44,770	61,353	55,373	74,498
Lead & Lead Ore ...	...	...	128,782	358,970
Magnesite	519	689	2,403	7,568
Manganese Ore (*a*) ...	79,443	631,760	822,876	1,052,403
Mica (*a*)...	80,120	170,126	230,747	373,370
Monazite	...	...	35,825	45,334
Petroleum	185,810	592,887	928,072	1,073,604
Ruby, Sapphire & Spinel	89,345	84,406	63,272	41,817
Salt (*b*)	347,897	451,339	507,294	902,623
Saltpetre (*a*)	262,603	268,012	240,289	474,188
Silver	...	...	9,341	135,929
Tin Ore & Tin	6,875	10,992	30,100	73,376
Wolfram	...	...	76,481	461,698
TOTAL ...	4,253,705	6,716,325	8,393,222	11,822,743

a = Export values. *b* = Prices without duty.

Table II

Value of certain Indian minerals produced during the years 1919, 1920 & 1921.

—	1919	1920	1921
	£	£	£
Amber	410	1,111	1,123
Chromite	59,149	53,313	36,492
Coal	6,746,104	6,198,568	8,673,377
Copper Ore	34,944	28,166	32,560
Diamonds	13,883	2,750	4,865
Gold	1,504,026	1,822,076	2,050,576
Graphite	546	373	52
Iron Ore	30,591	78,775	140,555
Jadeite	18,697	120,485	126,535
Lead & Lead Ore	445,761	650,618	784,586
Magnesite	13,152	11,470	15,632
Manganese Ore (*a*)	1,030,887	2,390,715	1,537,068
Mica (*a*)	575,632	710,292	426,274
Monazite	40,475	32,821	30,959
Petroleum	1,222,872	5,303,088	5,603,975
Ruby, Sapphire & Spinel ...	72,058	41,321	50,165
Salt (*b*)	1,215,681	964,272	742,147
Saltpetre	314,165	393,902	357.032
Silve	324,728	562,072	593,008
Tin Ore & Tin	160,766	217,084	162,770
Wolfram	359,696	93,138	29,292
Total ...	14,184,223	19,676,410	21,399,043

a = Export values. *b* = Prices without duty.

Indian mineral statistics are grouped officially into two classes, (1) those for which approximately trustworthy annual returns are available, and (2) those for which regular and complete particulars are not forthcoming. The first class alone is considered here. These statistics are of internal comparative value only, as an indication of the trend of the particular mineral industry with which they deal. For comparison with the absolute values of the mineral products of other countries they are in most cases useless. For example, the value of coal represents an approximate pit's mouth figure, which bears little relation to the selling price in the open market; the value of salt is exclusive of its duty, which is the main source of income derived by the Government from its manufacture; again, the export value of mica is not connected in any apparent way with the stated value of the production figures at the mines. Further instances might be given but these must suffice.

Although the general group movements may be made out from a study of statistics such as these, it is nevertheless necessary to analyse each case separately in order to visualise future tendencies even imperfectly. For this reason we shall consider individually, and, as briefly as is consistent with our purpose, all the chief minerals of the country. In a compilation of this kind assistance is obtainable from many sources, and it is impossible to enumerate all that I have used. I have drawn freely on the observations of practically all my colleagues, past and present, and I acknowledge my indebtedness to them collectively, but I am under particular obligations to the writers of the "Annual and Quinquennial Reviews of Mineral Production in India," Sir T. H. Holland, Sir H. H. Hayden, Dr. E. H. Pascoe & Dr. L. L. Fermor; to Sir Thomas Holland again for his "Sketch of the Mineral Resources of India" and to Mr. T. H. D. La Touche for his "Bibliography of Indian Geology and Physical Geography." Following the notes on each mineral I have added one or two references, though this is not intended to mean that the papers mentioned are in every case the latest, or only ones, on that particular subject, but that they may prove useful to the reader, desirous of following the subject on the same lines, further than the limited space at my disposal permits.

I have also used frequently the notes on Indian minerals written by myself, when attached to the Imperial Mineral Resources Bureau and the Office of the Indian Trade Commissioner in London, and published as "Bulletins of Indian Industries and Labour" in 1921 and 1922. These deal with the ores of manganese, lead, zinc, tin, chromium, tungsten, molybdenum, antimony, arsenic and bismuth; with bauxite, mica, asbestos, magnesite, monazite, corundum, garnet, barytes and the mineral colours. They were followed by others on sulphur and sulphuric acid, and on glass-making materials by Mr. C. S. Fox. Their chief object was to show the Indian producer, and particularly the small Indian producer, the manner in which manufacturers generally obtain their supplies, the systems of buying and selling, the regulations of the mineral trade associations, the standard specifications and contract forms of metallurgical firms and dealers, the recognised market grades and units of sale.

The classification adopted here is an alphabetical one, which, although it leads to apparent incongruities, possesses the great merit of simplicity.

Finally, I alone accept full responsibility for statements regarding the future development of any particular mineral industry, unless the opinions of others are quoted.

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AGATE

Agate, and its many varieties, carnelian, chalcedony, etc., are of frequent occurrence in the vesicular lava flows of the Deccan trap and are found in the beds of rivers draining regions covered by these rocks. The cutting and polishing of the stones is carried on at Jubbulpore in the Central Provinces, at Banda in the United Provinces and at a few other places within easy reach of the Deccan trap. The most important centre is Cambay, the capital of the State of the same name, in the Kaira Political Agency of Bombay. The stones used here, come from various areas on or near the edge of the trap; a large proportion of them from the State of Rajpipla where they are mined from a conglomerate at Ratanpur and Damlai. The first authentic accounts of the industry date from the early days of the sixteenth century, but it probably flourished long before that time. After sorting at the mines, the stones are taken to Limodra, where after lengthy exposure to sunlight and baking in earthern pots to improve the colours, they are reselected and sent to Cambay to be worked into bowls, knife handles, paper knives, pen holders, beads and trinkets. Many of the agate articles retailed in Europe originate from Cambay, and large quantities are exported to China.

The output from the Rajpipla mines, which are "farmed out" by the State for quinquennial periods at a fixed annual rental, varies from 100 to 500 tons per annum.

P. N. Bose: "Note on the Geology and Mineral Resources of Rajpipla State," *Rec. Geol. Surv. Ind.*, Vol. XXXVII, pp. 167–190 (1908).

ALUM

Many years ago, India's requirements of alum were satisfied from internal sources, by the solution of aluminium sulphate from burnt pyritous shales and the preparation of the alum itself, the double sulphate of aluminium and potassium, by treatment of the liquors so obtained with wood ashes. The process greatly resembles one which used to be worked in Europe, but is now discarded in favour of a later method using bauxite as a starting point. The consumption of alum and the aluminous sulphates is increasing in India, owing to the progress of general industrial activity and for the three years ending 1921, an average of 129,215 cwts. valued at Rs. 13,01,173, (£ 86,744), were imported annually. The old industry still lingers on in the Mianwali district of the Punjab, where two or three thousand cwts. are manufactured every year, mainly for use in the tanning and dyeing trades. Pyritous shales which might be utilised for making alum are known to occur in other places, and lately there has been more than one proposal put forward to revive the ancient industry on a small scale.

N. D. Daru: "Alum Shale and Alum Manufacture at and near Kalabagh, Mianwali district, Punjab." *Rec. Geol. Surv. Ind.*, Vol. XL, pp. 265–282, (1910).

AMAZON STONE

Large crystals of the opaque or very slightly translucent, green, potash felspar, known as amazon stone, occur with pink and blue tourmalines in the druses of a cavernous pegmatite, two miles south of Domchanch, Hazaribagh district, Bihar and Orissa. Specimens of this material examined by London jewellers were reported to possess an excellent colour but to be too fissile for cutting into ornaments.

AMBER

The fluorescent brown amber of Burma has been known to the Chinese for centuries. The mines are near Maingkwan, an isolated village in the Hukong valley, and they were first visited by Europeans in 1836. The amber is found in the form of irregular lumps in a blue clay, the whole outcrop of which is reported to have been dug over at one time and another in search for it. Pits varying from twenty to forty feet deep are also sunk into the clay. Amber is a fossil resin and it sometimes contains the remains of insects entrapped in the gum as it exuded from its parent tree. A recent study of the insects in Burmese amber, has led to the belief that it is of Eocene (Early Tertiary) age. The potentialities of the area are unknown, the demand for the substance is subject to the caprice of fashion, and the output of the mines varies greatly from year to year, since it depends to a great extent on pure chance and also on the inconsistencies of an indolent race. Twenty years ago production varied

between 100 and 200 cwts. per annum, but for the period 1914-1918 it averaged only 18 cwts. per annum. In 1921, 26 cwts., valued at Rs. 16,840 were returned. The decrease is said to be due to the superior attractions offered by the jade mines to the local labour. The right to collect a 5 per cent. *ad valorem* duty on amber is "farmed out" with the jadeite royalties.

The mineral finds its way partly to Têngyüeh, the jade-cutting centre of Yunnan, where it is made up into buttons and small ornamental articles, and partly to Mandalay, where beads for rosaries, *nadaungs* (the ear cylinders worn by Burmese women), and similar trinkets are made. Burmese amber beads are familiar objects in the bazaars of Calcutta and other Indian cities, but there are many excellent imitations of artificial origin on the market to attract the unwary purchaser.

F. Nœtling: "Preliminary Report on the Economic Resources of the Amber and Jade mines Area in Upper Burma". *Rec. Geol. Surv. Ind.*, Vol. XXV, pp. 130–135, (1892).

AMETHYST, ROSE-QUARTZ AND CAIRNGORM

Amethysts are often found in cavities of the trap rocks which cover so large a part of India; for example, they occur in outcrops of Deccan trap in the bed of the Narbada near Jubbulpore, and in the Rajmahal traps of Burhait in the Santal Parganas, Bihar and Orissa. The mineral is also common in the Sutlej valley in Bashahr, Punjab.

Good rose-quartz comes from the Chhindwara district, Central Provinces, while cairngorms and smoky quartz are collected from the beds of streams traversing the Cuddalor sandstones of the Tanjore district, Madras; from the Patna State of Orissa, from Kumaun and elsewhere.

These stones, like the agate, onyx, carnelian, chalcedony and others, are all varieties of quartz or silica.

ANTIMONY

The existence of antimony ores near the Shigri glacier in Lahaul has been known for 70 years, but the locality is so high and inaccessible and the climate so severe, that active exploitation has proved impossible. Stibnite, the sulphide of antimony, occurs at Thabyu, an isolated place near the Siamese frontier in the Amherst district of Burma. It has also been found in quartz veins in the Thaton district of the same province, and at a number of places in the Southern Shan States; none of these are promising from an economic standpoint. Small quantities of stibnite and antimony ochre have been reported from Chikkamanahali in the Chitaldrug district of Mysore, but the grade of the ore-body is stated to be poor. Tetrahedrite, or grey copper ore, a double sulphide of copper and antimony, has been found in certain copper-bearing lodes at Sleemanabad in the Central Provinces. Antimonial lead, containing from 15 to 20 per cent. of antimony, is produced as a by-product at the Nam Tu smelters of the Burma Corporation Ltd.; during the war the requirements of the Indian Ordnance Department were met from this source, and, in addition, the company exported early in 1918, 450 tons of antimonial lead containing 13·4 per cent. of antimony, together with some copper and silver.

Metallic antimony is an essential component of most of the "antifriction alloys." Mixed with tin and small quantities of lead and zinc it forms the "Britannia metals," which are employed in the manufacture of cheap tableware. Alloyed with lead and tin it yields the "type metals". It also forms an essential part of the alloys known as pewter, white bell-metal and hard lead. Some of its salts form valuable pigments and others are used in the manufacture of safety matches.

With the possible exception of some of the Burmese deposits, it cannot be said that any of the known Indian stibnite occurrences appear large enough, or sufficiently well placed from the point of view of cheap transport, to warrant any hope that they can be exploited profitably today.

A. M. Heron: "The Antimony Deposit of Thabyu, Amherst District, Burma". *Rec. Geol. Surv. Ind.*, Vol. LIV, pp. 31–43, (1921).

H. C. Jones: "Note on some Antimony Deposits of the Southern Shan States." *Rec. Geol. Surv. Ind.*, Vol. LIII, pp. 44–50, (1921).

APATITE

Gem apatite of a remarkable blue colour occurs with the ruby, sapphire and spinel at the Mogok ruby mines, Upper Burma. Apatite of a beautiful, deep sea-green shade is found at Devada, Vizagapatam district, Madras. A lavender-

coloured apatite has also been obtained at the Kodur manganese mines in the same district, but it is very flawed. Green apatite from the pegmatites of Ajmere in Rajputana is sometimes cut as a gem. Apatite is a phosphate of lime in part, and in addition to the precious varieties mentioned above, there are others which are utilised for their phosphorus content.

See Phosphates

AQUAMARINE

Aquamarine is the transparent, sky-blue or limpid variety of precious beryl, the same mineral which when of an intense green colour is known as the emerald. The principal source of Indian aquamarines is the immediate vicinity of Dasso village, Skardu Tehsil, Kashmir, where the gems are found in coarse pegmatite veins penetrating granite. The deposit was only discovered about 1915 and since then has yielded large numbers of these stones. Like most aquamarines they do not show any great depth of colour, but the delicate blue tint is very uniform, and their beauty is especially apparent when the stones have been cut in the "brilliant" form and are viewed in artificial light. Aquamarines and the precious beryls generally are amongst the lower priced jewels, so that it is not surprising to find that clear, transparent Kashmir crystals as found, are only valued at a few annas a ***rati***.

Aquamarines of blue and sea green shades were mined in the early decades of the 18th century at Padyur, in the Coimbatore district of Madras, where they again occur in a pegmatite vein. They have also been obtained from north of Ajmere and near Toda Rai Singh in Rajputana.

Pale green, hexagonal prisms of beryl are common in the mica-bearing pegmatites of Bihar and Nellore, where they often attain large dimensions, specimens having been seen with diameters measuring six inches to one foot. These huge crystals are too fissured and flawed, and of too poor a colour, to be of any value for cutting into gems.

The yellowish-green "aquamarine-chrysolite" occurs with bluish-green beryls in pegmatite veins near Melkote, Mysore.

C. S. Middlemiss and L. J. Parshad: "Note on the Aquamarine Mines of Dasso on the Braldu River, Shigar Valley, Baltistan". *Rec. Geol. Surv. Ind.*, Vol. XLIX, pp. 161–172, (1918).

ARSENIC

Orpiment, the sulphide of arsenic, used to be mined on a fairly large scale in Chitral. Small quantities of the mineral also find their way into the bazaars of Northern India from Kumaon. Other arsenic-bearing minerals have been discovered elsewhere, but no attempt seems to have been made to recover arsenic from them. Orpiment has been imported into Burma from the Chinese province of Yunnan for a great many years, and is extensively used as a pigment in the decoration of Burmese lacquer work, for when mixed with indigo it produces the green tints which are so much admired. Small amounts are also exported regularly to the Federated Malay States and to China, where it finds a use as a depilatory. Most of the arsenic compounds of commerce are obtained originally in the form of arsenious oxide (white arsenic), as a by-product in the smelting of copper and other ores, and there is no reason to suppose that mining operations for arsenical ores alone would prove profitable in India, even if suitable deposits were known.

J. Coggin Brown: "The Mines and Mineral Resources of Yunnan," *Mem. Geol. Surv. Ind.*, Vol. XLVII, pp. 142–145, (1920).

J. Coggin Brown: "Notes on Arsenic." *Bull, Ind. Inds. Lab.*, No. 6, pp. 15–19, (1921).

ASBESTOS

The term "asbestos," as it is understood in commerce, embraces a number of minerals which all possess the property of splitting into fibres that are capable of being felted and spun together. They may be divided into two groups:—(1) Serpentine Asbestos and (2) Amphibole Asbestos. The former group supplies 90 per cent. of the world's production of asbestos goods and is by far the more valuable of the two; Indian asbestos, unfortunately, as a rule, belongs to the second class. It is found in the Saraikela and other States of Bihar and Orissa, in the Idar State of Bombay, at many places in Mysore and in some of them it is obtainable in exceptionally long fibres.

It is impossible to enumerate here the multitudinous uses to which asbestos is put, and it must suffice to say that its fire and acid-resisting properties make it an indispensable material in modern civilization. It is spun into yarns

which are woven into fabrics, ropes and tapes; its shorter fibres are made into mill-boards, paper, boiler coverings and engine-packing materials; asbestos-cement preparations are finding increasing applications in the building trade. For all purposes in which really high grade asbestos is essential, the samples from India which have been tested abroad, have had practically no commercial value, as the fibres are too brittle to be spun; at the same time, there seems no reason why such products as asbestos-cement sheets, insulation materials for boilers and steam pipes, and fire-proof paints, should not be made from materials available at present in abundance. Canada produces about 85 per cent. of the world's serpentine asbestos, and the bulk of the raw fibre quarried in that country averages only $\frac{1}{4}$ to $\frac{1}{2}$ inch in length. There are large areas of rocks in India similar to those that are the home of asbestos in Canada and in Rhodesia, and they deserve more careful investigation on the part of prospectors than they appear to have received as yet.

W. F. Smeeth and P. S. Iyengar: "Mineral Resources of Mysore." pp. 134-136, (1916).

J. Coggin Brown: "Notes on Asbestos." *Bull. Ind. Inds. Lab.*, No. 20, (1921).

L. L. Fermor: "The Mineral Resources of Bihar and Orissa." *Rec Geol. Surv. Ind.*, Vol. LIII, pp. 252-253, (1922).

AVANTURINE

Max Bauer writes,—"Fine specimens of this mineral are occasionally met with in India, but nothing definite is known as to their mode of occurrence or the exact locality. A very pretty, green, glistening variety from the Bellary district of Madras deserves mention; the scales of mica enclosed in it are of the green chromiferous variety known as fuchsite and the mineral itself occurs in blocks from which slabs of considerable size can be cut".

This green quartzite occurs in a low ridge a few score yards south-east of Metra, on the road between Daroji and Kampli, Bellary district, Madras. According to Mr. Bruce Foote it would make a pretty material for inlaid stonework of the Agra type, or for mosaic work.

In Mysore, a uniformly rich bluish-green-coloured quartzite occurs near Belvadi, Hassan district, while a banded green rock is found near Sindagere, about 3 miles north-west of Belvadi.

It has been stated that green avanturines of this kind are very highly esteemed in China and are sometimes substituted for jade and jadeite, but specimens of South Indian fuchsite-quartzite, given to the jadeite cutters of Têngyüeh, Yunnan, by the writer, excited little interest owing to their brittleness.

Max Bauer: "Precious Stones," translated by L. J. Spencer, p. 503, (1904.)

V. S. Sambasiva Iyer: "Report on a preliminary mineral survey of parts of the Mysore and Kadur districts." *Recs. Mysore Geol. Surv. Dept.*, Vol. VI, pp. 35-38, (1906).

BARYTES

Barytes, the sulphate of barium, is a white mineral which finds its chief application in the paint industry and especially in the manufacture of lithophone. A large deposit of it exists near Betamcherla, in the Kurnool district of Madras. It occurs too at Sainpuri, Bhankhera, and other places in Alwar State, Rajputana; near Alangayam, Salem district, Madras; in the vicinity of the Bawdwin Mines, Northern Shan States, Burma, and at several localities in Baluchistan, Central India, the Central Provinces and Chota Nagpur. In 1921, 1,691 tons, valued at Rs. 52,283 (£3,485), were produced, of which 1,457 tons came from the Kurnool district alone. To be acceptable to the market, barytes should be in a fine, milled condition, and of a pure, unblemished, white colour There is no opening abroad for the crude, unground material for it is cheap and in pre-war years, the finest qualities were obtainable in the United Kingdom for £3 or £4 per ton There are large deposits in most of the European countrie and in America. The possibilities of the large-scal exploitation of the Indian deposits of barytes appear depend therefore on the future growth of the paint an colour industry in India itself.

J. Coggin Brown: "Notes on Barytes." *Bull. Ind. Inds. Lab.*, No. 22 (1921).

S. K. Roy: "Barytes in Alwar." *Rec. Geol. Surv. Ind.*, Vol. LIV, pp. 238-239, (1922).

BAUXITE

Bauxite is a hydrated oxide of aluminium and is very extensively used in its manufacture. Some years ago it was

discovered that many of the laterite deposits of India are highly aluminous, and investigations both in the field and the laboratory by officers of the Geological Survey, have proved that certain of them compare very favourably with those that are worked on a large scale in the United States of America, France, British Guiana and other countries.

The richest bauxite-bearing areas are situated on the Baihir plateau in the Balaghat district and in the neighbourhood of Katni, both in the Central Provinces. In addition to these, valuable ores have been found in the States of Sarguja and Jashpur, and in the districts of Mandla and Seoni, Central Provinces; in the Kalahandi State and Chota Nagpur, Bihar and Orissa; in Bhopal and Rewah States, Central India; in the Satara, Kaira and other districts of Bombay; in Mysore and in Jammu, Kashmir. Detailed descriptions of these and many other deposits are given in Mr. C. S. Fox's recently published memoir.

Besides its value as an ore of aluminium, bauxite has other applications. It is used in the preparation of alum and other salts, in the manufacture of artificial abrasives and bauxite bricks for furnace linings, and as a filtrating medium in the refining of mineral oils. At the same time, probably three-quarters of the bauxite quarried in the world finds its way to the aluminium factory, and it is in this direction rather than in that of any of the others, that there appears to be more hope for the modern exploitation of India's resources. Sixteen years ago Sir Thomas Holland showed that simple export of the raw material was impracticable, and this conclusion still holds good. He decided then that that the manufacture of pure alumina by extraction with alkali for export, involved smaller risks than the actual smelting of the ore and the production of the metal in India. During the last few years however, several concessions have been taken out, and the whole subject has received much consideration from industrialists and financiers. Moreover, the growth of the aluminium industry in other countries has been rapid, while the investigations of the Hydro-Electric Survey of India and of private firms, have together resulted in a wider knowledge of sites suitable for generating stations. The consumption of aluminium in India is small, though it will doubtless expand, but any works erected to make it at present would be compelled to dispose of a portion of their production by export. It is believed that the successful aluminium enterprises of other countries have depended more on cheap hydro-electric power and large scale production than on the other factors of the problem.

C. S. Fox: "The Bauxite and Aluminous Laterite Occurrences of India." *Mem. Geol. Surv. Ind.*, Vol. XLI, pt. 3, (1923).

BISMUTH

Although traces of bismuth are known to be present in some of the copper ores of Singhbhum, the only part of the Indian Empire where its ores are regularly seen, or where any attempt has been made to extract them on a very small commercial scale, is in the Tenasserim division of Lower Burma. In the Tavoy district, metallic bismuth and some of its compounds are found in the quartz veins which are mined for their wolfram and tin-ore contents. They have also been reported from the adjoining districts of Amherst and Mergui. The quantity of bismuth compounds in the veins is too insignificant to permit of their profitable extraction on this account alone, and the few hundredweights that have been shipped have been recovered as by-products in the course of sluicing operations for wolfram and tin-ore.

A. M. Heron: "Bismuth in Tenasserim." "*Rec. Geol. Surv. Ind.*," Vol. LIII, p. 81, (1921).

BORAX

The region from which Indian borax is derived commences at the Puga valley in the Ladakh division of Kashmir and passes east through Rudok into Tibet proper. In this tract of country there is a chain of lakes and dessicated lake beds from which the borax is obtained. The existence of borax in these trans-Himalayan regions has been known for a very long time and there is a reference to it in a work published in 1563. The trade reached its maximum about 1885, when the imports into India totalled about 1,600 tons, of which over 1,000 tons were exported, chiefly to the United Kingdom. Since then the export trade has died as far as Europe is concerned, owing to the discovery of natural borates in America and elsewhere. India's imports of borax today amount to about 1,000 tons per annum, and the exports by

sea, mainly to the Far East, to about 200 tons per annum. The extreme isolation of the borax lakes, the political conditions which render their examination impossible, and the almost insuperable difficulties of transportation over the highest mountains in the world, all combine to retard development: that the Tibetan borax will continue to be able to hold its own against imports from abroad is the utmost that can be hoped for.

J. Coggin Brown: "Notes on Borax." *Bull. Ind., Inds. Lab.*, No. 12, (1921).

BUILDING STONES

There are no reliable statistics in existence from which the extent of the trade in building stones and related materials such as road metal, clay or lime can be studied, for although the output of a few large private or State-owned concerns may be accurately known, the returns for the country as a whole are mere guesses. The materials used for ordinary building purposes and for road metal in any particular area depend almost entirely on the type of rock occurring close at hand. In the great cities of the plains, the majority of the buildings are usually built of locally made bricks and coated with stucco, but in many others the surrounding tracts furnish supplies of stone when these are required for more important purposes. The Vindhyan system of rocks which in its type area covers an immense territory, from Dehri-on-Son to Hoshangabad and to Gwalior, and from there to Agra and to Neemuch, carries in some of its divisions massive sandstones which yield some of the finest building stones of the Indian Empire. These sandstones, according to the late Mr. E. Vredenburg, "have yielded the material for the masterpieces of Indian art from the time of Asoka to the present day. Amongst the buildings of Vindhyan sandstone may be mentioned the Buddhist stupas of Bharut, Sanchi, and Sarnath; the exquisite temples of Kajraha; the palaces of Gwalior, Delhi, Agra, Fatehpur-Sikri, Amber and Dig; the magnificent Jumma Masjids of Delhi, Agra, and Lahore. According to which beds are selected, it is possible to obtain monoliths of Egyptian magnitude, or flags of the thinness of slates. Such a variety of excellent materials is obtainable that, in certain parts of

India, public buildings and private dwellings, from the flooring to the walls and to the rafters and ceilings are built entirely of stone. Large quantities of railing posts are manufactured out of Vindhyan sandstone, and, until a few years ago, it was the usual material for telegraph posts". In Calcutta the use of the varieties of Vindhyan sandstone known as Mirzapore and Chunar stone has greatly extended in recent years. In the southern part of the Peninsula, various igneous rocks, such as the charnockite series of Madras itself, and the gneissose granites of North Arcot and Mysore, are largely used; in the centre of Southern India, slates and limestones from the Cuddapah and other series of rocks. In Southern Bombay, parts of Hyderabad, the Central Provinces and Central India, basalt from the flows of the Deccan trap is quarried, while other parts of Central India and the Central and United Provinces draw on the incomparable sandstones of the Vindhyan system already mentioned. Sandstones of Gondwana age are used on and near the coal fields of Bengal, Bihar and Orissa and the Central Provinces. Basalts from the Rajmahal traps were used for the training works on the Ganges near the Sara bridge, and granite from Kalagauk, an island off the Amherst coast, between Moulmein and Ye, for those on the Rangoon River.

Laterite is a very important asset for building purposes. It is very widely distributed throughout India and parts of Burma and is extensively quarried. It possesses the peculiar property of changing from a soft material when freshly exposed, to a hard rock when it has been in contact with the air for some little time.

In the limestone group the foraminiferal stone of Porbandar deservedly enjoys a high reputation and is used on a large scale in Bombay and Karachi. In the Central Provinces, according to Dr. Fermor, the best known material is the marble of the Jubbulpore district, but numerous excellent marbles occur in the Betul, Chhindwara, Nagpur and Seoni districts as well. Serpentine marbles are found in the Saugar tehsil of Chhindwara. Crystalline limestones and marbles from the older geological formations of India and Burma constitute ornamental stones of unrivalled beauty. The white and pink

marbles of some of the Rajputana States, such as Jodhpur, Kishengarh and Ajmere deserve especial mention. The Victoria Memorial in Calcutta is entirely built of marble from the Mekrana quarries in Jodhpur. Some of the limestones of the Lower Vindhyan series also show strikingly beautiful effects on polishing, and have been used in the inlaid decoration of historic buildings in Agra. The famous Taj at Agra is built mainly of white Mekrana marble, with elaborate inlaid work of yellow marble and shelly limestone from Jaisalmer, onyx marble from the Salt Range, black, calcareous shales from the Vindhyans of Chitor, malachite from Jaipur, carnelians and blood-stones from the Deccan trap and red jasper from the Gwalior series.

Slates are quarried at many places in the Outer Himalayas; in the Kangra district and near Rewari in the Gurgaon district of the Punjab, and in the Almora and Garhwal districts of the United Provinces. In the Kharakpur Hills, Monghyr district, Bihar and Orissa, a company produces fine slabs which are used for many purposes, including flooring and ceiling slabs, roofing slates, school slates and electrical switchboards.

In spite of the fact that India possesses superb ornamental stones, the importation of Italian marble for flooring, etc., still continues unabated, because it is put on the market at cheap rates and in a condition fit for immediate use by the buyer. During the past few years, the materials used in building construction and allied forms of engineering, imported from foreign countries into India, have had an average annual value of nearly Rs. 105 lakhs (£700,000), exclusive of stone and marble, which have averaged approximately Rs. $4\frac{1}{2}$ lakhs (£30,000), per annum in the same period (1914-1918).

In the compilation of this note Sir T. H. Holland's article has been quoted freely.

Sir T. H. Holland: "Sketch of the Mineral Resources of India." pp. 43-46, (1908).

CEMENT-MAKING MATERIALS

Large quantities of cement are used in India, and the imports for the three years 1912 to 1914 averaged about 150,000 tons per annum, of which about 84 per cent. came from the United Kingdom. During the war several firms installed modern plant and commenced making cement on a large scale, while today there are other works in the course of construction. The chief raw materials required are chalk or limestone, and clay, or similar substances containing the requisite calcareous and argillaceous bodies. These are pulverized to ensure intimate mixture, and are then calcined in kilns or rotary furnaces, after which the burnt product is reduced to a fine powder to enable it to be mixed with water and to set and harden.

At the Bundi Hydraulic Lime & Cement Company's works, situated near Lakheri in Bundi State, Rajputana, an argillaceous limestone of Upper Vindhyan age is used. The use of clay is unnecessary, as the correct proportions of lime, silica and alumina can be obtained by blending various varieties of the limestone together. The small quantity of gypsum, which is added to the "clinker" to correct its setting-time, is imported from Jodhpur and Rerwar.

The Lower Vindhyan limestones of Katni and their overlying clays are used by the Katni Cement & Industrial Co., Ltd. The same geological division near Rohtasgarh and Dehri-on-Son (Shahabad district), contains the important horizon known as the Rhotas limestone, which is extensively quarried by several lime-making companies at present, and which, with its associated shales, is to be used by the British Portland Cement Company in their works at Japla, Palamau district, Bihar and Orissa.

On the other side of India, the Indian Cement Co., with its works at Porbandar in Kathiawar, uses the pure miliolite limestone so well known as "Porbandar Stone," while the silica content of the local clay is improved by the addition of a powdered granophyre from the Barda Hills.

Experiments conducted recently in the Technological Institute of the United Provinces seem to show that good cement may be made from mixtures of marl and clay obtainable in the vicinity of Lucknow and of Cawnpore ***kankar*** and Sutna limestone.

Manufacturers claim that Portland cements made in India are equal to the best English brands, while imported cements

not infrequently deteriorate in the course of a long sea voyage, yet very considerable quantities continue to come into the country; thus, for the three years ending 1922, an average annual figure of 126,397 tons was reached, valued at Rs. 1,24,83,493 (£832,233).

H. A. F. Musgrave. "Report on Portland Cement of Indian Manufacture," Indian Munitions Board, (1918).

E. R. Watson, K. C. Mukerjee & N. G. Chatterjee. "The Possibilities of manufacturing Portland Cement in the United Provinces." *Bull. Ind. Inds. Lab.*, No. 30, (1923).

CHROMIUM

The mining of chromite, an iron ore containing chromium, commenced in Baluchistan in 1903, in Mysore in 1907 and in the Singhbhum district of Bihar and Orissa in the same year.

The Baluchistan deposits consist of veins and segregated masses of the mineral in serpentines of upper Cretaceous age, distributed along the hills bordering the Zhob valley, and the upper part of that of the Pishin river. The chief mines are near Hindubagh. The mineral has been found at many places in the Shimoga, Hassan and Mysore districts of Mysore State, notably in the Nuggihalli schist belt to the south-south-east of Arsikere, and near Shinduvali to the east of Kadakola. It occurs as segregations and bands in partially serpentinised rocks forming Roru Buru, Kimsi Buru and other hills west of Chaibasa, in the Singhbhum district of Bihar and Orissa.

For the five years ending 1914, the average annual production of chromite in India was approximately 4,000 tons. Following a slump in 1915, output rose steadily to a maximum of 57,770 tons in 1918. In 1921, 34,762 tons, valued at Rs. 5,47,382 (£36,492), were produced; 25,000 tons of the latter came from Baluchistan alone.

Chromite is the source of ferro-chrome, an alloy employed in the preparation of chrome steel and of "rustless" steel. It is also a useful refractory material and furnishes a neutral lining for steel, lead and copper furnaces. The salts of chromium and especially the alkaline chromates, are of considerable importance in the arts. New Caledonia and

Rhodesia are India's chief competitors in the chromite markets of the world.

W. F. Smeeth & P. S. Iyengar: "Mineral Resources of Mysore," pp. 110-116, (1916).

J. Coggin Brown: "Notes on chromite," *Bull. Ind. Inds. Lab.*, No. 9, (1921).

CHRYSOBERYL

Flat crystals of pale yellow chrysoberyl have been obtained from Kangayam in the Coimbatore district of Madras, and from Ramidi in the Talchir State of Orissa, but they are of no value as gems owing to the numerous flaws that they contain. They do not exhibit the chatoyant sheen which is so prized in this gem. Yellow crystals of good quality are said to occur in pegmatite veins at Govinsagar, Kishangarh State, Rajputana, together with aquamarines.

CLAYS

No statistics for which any degree of completeness can be claimed are available to show the undoubtedly great industrial value of the clays or clay products of India. They include the common clays used everywhere for the manufacture of bricks, tiles, earthernware and the cheaper kinds of pottery; the better varieties used for the opaque and semivitreous articles, covered with a dull glaze and decorated often with cobalt blue colours, such as the well known Jaipur and Moradabad vases; the fire clays which are known to occur in many of the provinces and which are worked on some of the Gondwana coalfields for manufacturing various refractory articles, the fuller's earth won near Jubbulpore, the *terra-cotta* used in the preparation of stone-ware, roofing tiles, ornamental facing bricks, etc., and the edible clays, often of a kaolinitic nature which are consumed throughout India and Burma. In addition to the common varieties, there exist in India many varieties of kaolin and white clays of finer qualities which are worked for use in the potteries that have sprung up in numerous centres of recent years, such as those of Calcutta, Gwalior, Jubbulpore and Raniganj, where, however, the main products are drain pipes, fire bricks and tiles. The potteries of Calcutta for example, make cups, saucers, jugs and similar domestic utensils, as well as insulators and

fancy articles, of common white porcelain from the kaolin of Patarghatta and Mangal Hat in the Rajmahal Hills. There can be no doubt that India has within her own boundaries all the essential raw materials for the manufacture of earthernware and porcelain of any quality, but the value of the raw materials and finished goods which are imported from abroad is still very great, and during the three years ending 1922 averaged over 1 crore and 35 lakhs of rupees per annum. (It is interesting to note that in 1922 china clay from the Federated Malay States made its first appearance on the Indian market. The geological conditions under which the china clay of the Federated Malay States occurs are very similar to those which prevail in some parts of the Tenasserim division in Lower Burma, where, however, no kaolin is produced). The materials included in the figures given above include bricks and tiles, cement, chalk and lime, clay and earthenware pipes, china clay, as well as manufactured porcelain and earthenware. The occurrences of materials used in the manufacture of Portland cement have been treated separately.

COAL

With the exception of the United Kingdom, India now produces more coal than any other part of the British Empire. To this country itself, coal is its most valuable mineral product, for over 90 per cent. of the output is consumed by its railways and industrial concerns of all descriptions. An output of about 1 million tons per annum was reached in 1880, and since then it has grown continuously until 1919, when the record production of over 22½ million tons was attained. The table given below shows the decrease which has taken place recently. The demand for coal in India is so great that large quantities have to be imported to supplement the home supplies, and corresponding with the low production of 1921, there was a record import of over 1 million tons, which came mainly from the United Kingdom, South Africa, Australia and Japan. In normal times India also exports coal, often up to as much as nearly 1 million tons per annum, the chief markets being Ceylon, and the Straits Settlements, and the smaller ones Aden, Java and Sumatra.

Production of Coal during the years 1917 to 1921

Year	Quantity (tons)	Value at the mines (per ton) Rs. a.
1917	18,212,918	3 11
1918	20,722,493	4 6
1919	22,628,037	4 8
1920	17,962,214	5 3
1921	19,302,947	6 12

The growth of the coal mining industry may also be gauged by the fact that in the official year 1912–13 there were 139 joint-stock coal companies in existence, with a total paid up capital of Rs. 716 lakhs, whereas in 1921–22, the corresponding figures were 276 companies and Rs. 1,013 lakhs. These figures by no means represent the total capital invested in the coal mines of India, as they do not take into account the funds employed by private individuals and syndicates.

About 97 per cent. of the coal is obtained from the Lower Gondwana rocks of the Peninsula. The remainder is won from Tertiary rocks of extra-Peninsula areas.

Many of the coal mines in India are shallow, though there is of course a tendency for them to become deeper, especially on the older fields. The industry finds a livelihood for over 200,000 labourers and could doubtless absorb more if they were forthcoming. Scarcity of labour is often one of the causes of low outputs. The great majority of those employed are aboriginal Dravidians from the highlands of Chota Nagpur and the Central Provinces, and many of them are cultivators as well as miners, who insist on returning to their homes at the sowing and reaping seasons. The use of machinery is rapidly extending and at the larger collieries, modern plant is the rule rather than the exception. Central power stations supplying electricity to groups of collieries have been erected. Several batteries of by-product recovery coke ovens are in operation. The practice of coal cutting by machinery is extending. Yet, in spite of noteworthy exceptions, present day methods of coal mining in India are accompanied by much avoidable waste of one of the most valuable assets the country possesses.

THE GONDWANA COALFIELDS

BENGAL, BIHAR AND ORISSA

The producing coalfields of Bengal, Bihar and Orissa belong mainly to what is known as the Damuda valley group. They are isolated patches of Gondwana strata, faulted down into the ancient crystalline rocks which build up the surrounding country.

Raniganj

The easternmost of the group, the Raniganj field, situated from 120 to 140 miles north-west of Calcutta, is the largest, with an area of 500 square miles. The most recent estimates of its reserves give 518 millions of tons of first class coal, in the three best seams, the Dishargarh (18 feet), the Sanctoria (10 feet) and the Sibpur, (12 to 18 feet) thick; 360 millions of tons of medium quality coal in the Ghusik (12 feet), the Raniganj (15 feet), and the Lakdih-Salanpur (20 feet) seams,* while the quantity of second class fuel totals thousands of millions of tons. The earliest attempts at mining in this field date back to 1812, but little profitable work was done until 1843. In 1854 the East Indian Railway reached Raniganj, and, until 1905, it headed the list as the chief producer. In 1906, its output (at that time 37 per cent. of the total) was surpassed by that of Jherria (with 42 per cent. of the Indian total). In 1921 it produced 5,211,855 tons, being 27 per cent. of India's total.

Jherria

The next field, 16 miles further west, is known as Jherria. Here, the existence of coal was certainly known before 1777, but mining was not undertaken seriously until about 1895, when the East Indian Railway reached it. The total area of coal-bearing rocks is about 150 square miles. The best coals occur in what are called the Barakar beds in which 18 seams, varying from a few feet to 100 feet or so in thickness, have been found. The nine lowest are, as a rule, of poor quality and work is confined chiefly to Nos. 10 to 18. The quantity of first class coal has been estimated at 480 millions of tons, but other estimates of coal of superior quality put the reserves at a much higher

* L. L. Fermor: "Mineral Resources of Bihar and Orissa." *Rec. Geol. Surv. Ind.*, Vol. LIII, p. 262, (1922).

figure. As in the case of the Raniganj field, there are vast stores of more inferior material. Jherria occupies the proud position of India's premier producing field, and with an output of 10,068,856 tons in 1921, accounted for no less than 52·16 per cent. of the total output.

Bokaro

Continuing further west still for two or three miles, we find the Bokaro field with an area of 220 square miles, where by 1910 three collieries were being prepared. In 1919 rail connection was established by the Bengal Nagpur Railway and since then development has been rapid. A remarkable feature about this field is the enormous thickness of some of its seams, thus the Kargali, on which the largest mines are situated, varies from 75 to 120 feet in thickness and its coal produces a good, hard, blast furnace coke. From this single seam alone, provided its characteristics persist over the area in which it has been proved, it has been estimated that 650 millions of tons will be available. The output in 1921 approximated 930,000 tons.

Ramgarh

The small field of Ramgarh, with an area of 40 square miles, lies about 5 miles south of the Bokaro field. It is traversed by the Damuda river, in the bed of which the coal crops out at numerous places.

North and South Karanpura.

The extensive coalfields of North and South Karanpura, with areas of 472 and 72 square miles respectively, lie at the base of the southern scarp of the Hazaribagh tableland, from one to two miles west of Bokaro. A number of thick seams have been proved and companies have been formed to mine them. In the meantime a railway connection is being made. Mr. Hughes of the Geological Survey of India, who surveyed the fields in 1867–68, estimated in the northern field the presence of 8,750 millions of tons of coal, and in the southern field 75 millions of tons, and pointed out that these estimates were extremely conservative ones. Some of the coal is said to be of excellent quality.

Chope, Itkhuri, Auranga and Hutar

The undeveloped coalfields of Chope, Itkhuri, Auranga and Hutar are all situated on the Hazaribagh plateau. Surveys

have been made with the object of determining the feasibility and cost of putting them into communication with the main lines of transport. For details regarding them the publications of the Geological Survey of India should be consulted.

Daltonganj

The Daltonganj field is in the Palamau district and its coal-bearing rocks have an area of about 30 square miles. The distribution of the coal appears to be irregular and there is apparently only one seam which is likely to yield any large quantity of coal. Mining was commenced here in 1842, but ceased in 1862 until 1901, when railway communication was established. The output for 1921 was 36,590 tons.

Giridih

The other producing fields of Bihar are Giridih, Jainti, Rajmahal and Sambalpur (Rampur). The Giridih field, situated in the sub-division of the same name in the Hazaribagh district, and about 200 miles from Calcutta, has an area of only 11 square miles, but it is of great importance on account of its position, and the fact that it produces one of the best steam coals in India. This has been mined from the year 1857, but railway connection was not established until 1871, since when development has been vigorous. In 1894 it was estimated that 82½ millions of tons of coal were still obtainable from the field, but since then some 22 millions of tons have been extracted. The output in 1921 was 818,580 tons.

Jainti

Jainti is a small field situated in the south of the Santal Parganas in the neighbourhood of the Adjai river. Coal was extracted as early as 1909 but proper mining dates from 1914. The seams are thin and the coal is dull black in appearance. The maximum output was reached in 1919, when over 105,000 tons were raised, but since then it has fallen to 105,652 tons in 1921.

Rajmahal Hills

Coal-bearing rocks occur in five small detatched areas in the Rajmahal Hills, but the seams are thin and poor and are only quarried on a very small scale for local purposes. The output in 1921 was 2,170 tons.

Sambalpur (Rampur)

The Sambalpur (Rampur) field is the most easterly extension of the Chhatisgarh coal-bearing area. It is of large extent and several thick seams of somewhat inferior quality are known to exist in it. Mining commenced on a seam of better quality in 1910, and in 1921, 77,277 tons were raised.

Talchir

Mention must also be made of the Talchir field in the valley of the Brahmani river in Orissa, where, during 1921, the existence of considerable quantities of good steam coal was proved. This field is now being opened up and a railway is under construction to it.

COALFIELDS OF CENTRAL INDIA

Umaria

The Umaria coalfield is the smallest of the rich coalfields of the Rewa-Gondwana basin. It has an area of 6 square miles and is estimated to contain 24 millions of tons of coal. It was opened up by the Government of India in 1882, but the mines were handed over to the Rewa State in 1900, since when they have been a source of considerable revenue to the Durbar. The Bilaspur-Katni branch of the Bengal Nagpur Railway passes through the field. Its average annual output for the years 1914-1918 was 178,000 tons, and for the year 1921, 154,974 tons.

Sohagpur

The Sohagpur field is approximately 40 miles south-east of Umaria. It has an area of over 1,500 square miles and although the number of coal seams is small, yet the lateral extent is so great, that a very large amount of coal is probably available at shallow depths. Small quantities are now being won from quarries, the output in 1921 being 37,060 tons.

Amongst the undeveloped coalfields of Central India those of Korar, Johilla and Singrauli should be mentioned.

COALFIELDS OF THE CENTRAL PROVINCES

Mohpani

The producing fields of Mohpani and the Pench Valley lie within the Satpura basin, in which the coal measures crop out at intervals from beneath younger rocks. The Mohpani coalfield is the most northerly of the group, and the exposed coal-bearing rocks

cover about 1 square mile. There are four seams, estimated in 1912 to contain 8,000,000 tons of coal. Mining commenced in 1862 and the output in 1921 was 89,623 tons.

Pench Valley

The Pench Valley field has an area of 7·4 square miles and is one of five semidetached areas often referred to as the Chhindwara coalfields. There are three seams which are believed to contain not less than 100,000,000 tons of coal. Mining commenced in 1905 and the output in 1921 was 449,311 tons.

In addition to the Mohpani and Pench Valley fields, the Yeotmal and Shahpur (Betul) fields produced 2,345 and 210 tons respectively in 1921.

Warora, Bellarpur, Sasti and Gugus

There are several coalfields in what is known as the Wardha Valley group, including Warora, which has been estimated to contain 20 millions of tons of coal, but where mining was abandoned in 1906 owing to insuperable difficulties caused by floods, fires and subsidences; Bellarpur where operations commenced in 1906, and from which 171,425 tons were won in 1921, and which extends across the Wardha river into Hyderabad (the Sasti coalfield). From the Sasti field 42,674 tons were obtained in 1921. This group is estimated to contain 60 millions of tons of coal. The Gugus area covers about 3 square miles with estimated contents of 45 millions of tons. Other areas with considerable reserves are those of Wun and Bandar.

Korea coalfields

The coalfields of the Korea State in the Central Provinces were specially investigated in 1913 by Dr. Fermor of the Geological Survey of India. They consist of Koreagarh, with an area of about 6 square miles; Kurasia, with an area of about 48 square miles, and in two sections of which alone, 10 to 20 millions of tons of coal exist, with possibilities of considerably larger amounts; and Sanhat, which is the name given to that portion of the Sohagpur coalfield lying within Korea State. The last field is believed to contain considerable quantities of coal.

There are other important but unworked coalfields in Chattisgarh and the Chattisgarh Feudatory States including those of Jhilmilli and Sarguja and others. All these coalfields belong to the Barakar division of the Lower Gondwanas, and, speaking generally, the coals themselves are not as good as the first class coals of Bihar and Orissa.

COALFIELDS IN HYDERABAD STATE

Singareni

In addition to the Sasti coalfield mentioned above, the Gondwana coal measures come to the surface near Yellandu in Hyderabad. The field has an area of 9 square miles and the principal seam was estimated to contain 45 millions of tons of coal in 1894. The output in 1921 was 646,047 tons. The coal from the Singareni field is mainly consumed by the railways and principal industries of Southern India.

THE TERTIARY COALFIELDS

Coalfields of Assam

Makum

The Makum coalfield is the most important of all the Tertiary coalfields of India. It lies amongst the lower ranges of hills which form the southern boundary of the Lakhimpur and Sibsagar districts. Seams of good coal also exist in the Nam-chik valley. The coal-bearing rocks to which this field belongs stretch for 40 miles to the north-east, and have been traced for 100 miles to the south-west, along the front of the Patkai Range. The seams vary from 15 to 75 feet in thickness, but, near Margherita, where most of the mines are situated, the average thickness is about 50 feet; in the Namdang section it increases to 80 feet and is persistent for 6 miles. Between the Tirap and Namdang fields it has been estimated that there is a total of 90 millions of tons of coal above ground water level. Extensive operations commenced in 1881, when a railway, 77 miles in length, was built to join up the Brahmaputra river near Dibrugarh with the field. In 1884 the output was 16,500 tons, and in 1921 about 269,200 tons. The coal is of fine quality but it has two faults—one its friability, and the other its high sulphur content. It is of an unusually bright colour. It is exceedingly low in ash and is a valuable gas coal. In addition to this it yields an excellent coke.

Nazira

The Nazira field lies to the south-west of Makum. It yielded 42,824 tons in 1921. The quality of the coal is said to be similar to that of Makum, but of a somewhat harder character.

Khasi Hills, etc.

There are several small coalfields in the Khasi Hills from which a few hundreds of tons are taken annually for local consumption. Other Tertiary coals are known to occur at numerous localities in Assam, and for details regarding them the publications of the Geological Survey of India should be consulted.

COALFIELDS OF BALUCHISTAN

Khost and the Sor Range

Rocks of Tertiary age sometimes containing thin coal seams occur in Baluchistan, but the strata in which they are found are soft and friable, as well as greatly disturbed by earth movements, so that mining is carried on under difficulties and the special precautions that have to be taken against more than usual dangers, render it expensive as well. In addition to the small mines of the Sor range to the south-east of Quetta, and in the Bolan pass at Mach, collieries have been worked since 1877 at Khost on the Sind-Pishin Railway, where two seams have an average thickness of 26 and 57 inches respectively. The output from Khost alone in 1921 was 22,100 tons, but the small amounts won in the Kelat State and the Sor Range increased the provincial total to 54,627 tons.

COALFIELDS OF BURMA

Coals of Tertiary age have been found in several parts of Burma, but no mining on a large scale has been attempted yet. Amongst other localities, the following may be mentioned :—the thin seams of poor coal of Mithwe, Bhamo district; the coal measures of the Kalé and other valleys in the Upper Chindwin; the occurrences of the Henzada, Shwebo and Pakokku districts; the Kamapyin-Tendau field in Mergui, and the coal measures of the Northern Shan States, which occupy a number of detatched basins grouped around the base of the mountain Loi Ling. A portion of one of these,—Namma, has been opened up by the Burma Mines Ltd., and two seams of average thicknesses of **12** and **21** feet of lustrous, black lignite proved. According to Mr. Moldenke, the mining engineer in charge of the exploration, there are 50 millions of tons of coal in the lower seam and **30** millions of tons in the upper one.

The Loi-an coalfield near Kalaw, is of Gondwana age and contains irregular seams of crushed coal, some of which appears to be of good quality.

E. Moldenke: "Geology of the Namma coalfield, Burma." *Trans. Amer. Inst. Min. Eng.*, Vol. LXVI, pp. 299-302, (1922).

COALFIELDS OF THE PUNJAB

Dandot

The coal mines of Dandot and of Pidh are situated on the plateau of the same name in the Jhelum district, where one thin seam, varying from 18 to 39 inches in thickness, forms a basin under the Nummulitic limestone. The mines were worked for the North Western Railway from 1884 until **1912**, when they were sold to a private concern. There are numerous small mines in the Jhelum district, the total output from which has increased from about **36,000** tons in 1919, to over 50,600 tons in **1921**. This is still far below the maximum of over **81,000** tons reached in 1899.

Coal seams similar to those of the Jhelum district are also mined on a small scale in the Mianwali and Shahpur districts, and have yielded from 10,000 to 16,000 tons per annum. In **1921** the total production of the Punjab was **67,242** tons.

COALFIELDS OF RAJPUTANA

Palana

A brown coal of Middle or Lower Tertiary age which occurs in a seam some 20 feet thick, has been mined since 1898 at Palana in the Bikaner State, for use in the locomotives of the Jodhpur-Bikaner Railway. Over 45,000 tons were raised in 1904, but after that there was a gradual decline to about 13,000 tons, taking an average over some years up to 1918. Since then, however, there has been a well-marked increase to **24,500** tons in **1921**.

V. Ball & R. R. Simpson: *Mem. Geol. Surv. Ind.*, Vol. XLI (1913).

Output of Coalfields in Gondwana Rocks for the five years 1917—1921

—	1917	1918	1919	1920	1921	Per cent. of total in 1921
	Tons	Tons	Tons	Tons	Tons	
Bengal Bihar & Orissa—						
Daltonganj ...	79,627	81,816	63,200	39,100	36,590	0·19
Giridih ...	824,007	846,592	950,000	831,300	818,580	4·24
Jainti ...	86,894	140,373	154,900	119,600	105,652	0·55
Jherria ...	9,783,788	10,952,010	12,145,900	9,294,000	10,068,856	52·16
Ramgarh Bokaro ...	360,760	541,977	722,700	864,400	929,143	4·82
Rajmahal ...	...	...	...	...	2,170	0·01
Raniganj ...	5,376,022	6,368,519	6,815,100	4,997,700	5,211,855	27·00
Sambalpur ...	52,892	51,038	45,600	37,000	77,277	0·40
Central India—						
Umaria ...	198,407	199,975	182,100	158,100	154,974	0·80
Sohagpur ...	...	...	...	...	37,060	0·19
Central Provinces—						
Mohpani ...	71,693	78,792	85,300	83,300	89,623	0·47
Pench Valley ...	204,502	267,303	285,400	279,500	499,311	2·33
Bellapur ...	95,303	135,375	126,400	128,200	171,425	0·89
Yeotmal ...	...	...	...	200	2,345	0·01
Shahpur ...	...	...	...	...	210	—
Hyderabad—						
Singareni ...	680,629	659,122	662,200	694,100	646,047	3·35
Sasti ...	...	...	...	...	42,674	0·22
TOTAL ...	17,814,524	20,322,892	22,238,800	17,526,500	18,843,792	97·62

Output of Coalfields in Tertiary Rocks for the five years 1917-1921

—	1917	1918	1919	1920	1921	Per cent. of total in 1921
ASSAM						
Makum, &c. ...	301,500	294,500	293,270	325,500	312,765	1·62
BALUCHISTAN						
Khost (Sibi dist.) ...	29,500	29,000	23,700	22,500	31,253	0·28
Quetta—Pishin dist. ...	...	...	5,700	5,100	10,902	
Kalat State ...	11,300	14,100	5,200	6,300	12,472	
PUNJAB (SALT RANGE)						
Jhelum dist. ...	40,500	39,900	35,800	47,800	50,639	0·35
Mianwali " ...	2,900	5,200	5,800	6,800	11,852	
Shahpur " ...	6,600	5,600	5,200	3,500	4,751	
RAJPUTANA						
Bikaner ...	6,100	11,300	14,800	18,200	24,521	0·13
TOTAL ...	398,400	399,600	389,200	435,700	459,155	2·38

COBALT

A complex ore of cobalt known as *sehta*, probably consisting of a mixture of two cobalt-bearing minerals, cobaltite and danaite, occurs with copper ore in the form of minute, silvery crystals, sparsely scattered through the black slates of the Babai copper mines, Khetri State, Rajputana. The mines have been closed, as far as copper is concerned, for many years, and the extraction of *sehta* ceased about 1908. It used to be recovered by crushing the slate and washing the powder in water. The heavy concentrate was sold to the jewellers of Jaipur, who used it for making the beautiful blue glazes of their enamelled work. Its place is now taken by a more expensive but better substance containing cobalt, which is imported from abroad.

Small quantities of cobalt have been detected in certain Indian manganese ores and in the sulphide ores of the Tovala taluk, Travancore. An incrustation of a pink mineral containing cobalt and known as erythrite, has been noticed on heaps of the Bawdwin lead and zinc ores after continued exposure to the weather.

A. M. Heron: "Geology of Western Jaipur," *Rec. Geol. Surv. Ind.*, Vol. LIV, pp. 387-388, (1923).

COPPER

Copper ores have been smelted in India since prehistoric times and it is believed that the industry was a comparatively large one in the middle ages in Southern India, Rajputana and elsewhere. Minerals containing copper have been found in practically every province, but only the larger occurrences can be mentioned here.

In the Singhbhum district of Bihar and Orissa, there is a copper-bearing zone of country, demarcated by ancient workings and persistent for 80 miles. These old mines, and others in Hazaribagh district and the Santal Parganas, were the scene of much unsuccessful prospecting in the second half of last century. In the years 1906-1908, the Singhbhum deposits were systematically drilled by the Geological Survey of India in certain selected spots. The results then obtained led later to the sinking of a deep shaft at Rakha by the Cape Copper Co. Ltd., and to exploratory work which has proved the existence of large reserves of ore. A concentrating mill, smelter and refinery have been built, and form the only copper producing plant within the limits of the Indian Empire to-day. Smelting was commenced in 1918, and resulted in the production of 980 tons of the refined metal in 1919, 512 tons in 1920 and 1,143 tons in 1921. According to Dr. Fermor, the copper ores occur in rather indefinite lodes interbedded with Dharwar schists; sometimes the ore is collected into fairly well-defined bands, but very frequently it occurs in the form of grains, so sparsely disseminated through a considerable thickness of schists as to be unworkable. The chief ore mineral is chalcopyrite, a sulphide containing both copper and iron.

Several attempts have been made during the last sixty years to re-open the old copper mines of Baragunda, in the Hazaribagh district, and in 1888, one company produced 218 tons of refined copper there. The deposits are again under investigation at present.

An extensive literature exists on the copper deposits of Kumaon, a division of the United Provinces, situated to the westward of the Kingdom of Nepal in the Himalayas. Most of it dates back to the first half of last century, when the local industry, which is believed to have flourished under the Gurkha occupation, had become moribund. The value of the deposits is quite uncertain.

Copper-bearing lodes of possible value have been found at a large number of localities in Sikkim, and their origin and mode of occurrence appear to be somewhat similar to those of the copper lodes of Singhbhum. They differ from the latter however in the diversity of their mineral contents, which include the sulphides of lead and of zinc as well as that of copper. The two largest occurrences are situated at Bhotang and Dikchu respectively. Prospecting operations were suspended during the war and have not been resumed.

In the notes on lead and zinc, it is shown that chalcopyrite occurs with the lead—silver and zinc ores of Bawdwin in the Northern Shan States of Burma, and more especially in the Shan orebody of the Vertical Shaft section of that mine. At the end of 1921, the reserves of this grade of ore totalled over 335,000 tons containing an average of 11 per cent. of

copper. For the quinquennial period ending 1918-1919, the values of the average annual consumption of copper and brass in India were over 120¼ lakhs of rupees (£801,723) and over 77½ lakhs (£517,057), respectively, as against nearly 310 lakhs (£2,066,395), and 10½ lakhs (£70,008), respectively in the previous quinquennium. These figures alone show what wide space there is for the expansion of India's own copper industry.

P. N. Bose: "Notes on the Geology and Mineral Resources of Sikkim," *Rec. Geol. Surv. Ind.*, Vol. XXIV, pp. 217-230, (1891).

L. L. Fermor: "Mineral Resources of Bihar and Orissa," *Rec. Geol. Surv. Ind.*, Vol. LIII, pp. 262-264, (1922).

COPPERAS AND BLUE VITRIOL

The soluble sulphate of iron (copperas) and the corresponding copper compound (blue vitriol), used to be made on a fairly large scale from decomposed pyritous shales, usually as by-products in the indigenous industry for the manufacture of alum from alum shales, but the process has practically collapsed before the importation of cheap chemicals, and only lingers on in a few localities such as Singhana and Khetri in Rajputana. Dr. Heron who visited these places recently, reports that at Singhana, about a dozen men and at Khetri, two men, were employed in steeping the effloresence which is found coating the walls of the old copper mines, together with fragments of weathered shale, and evaporating the liquor so obtained to extract the mixed salts, the sulphates of copper, aluminium and iron. This mixture, in which copper sulphate is probably the chief ingredient, is known as *nila-thotha* and was sold in pre-war days at Rs. 7/- per *maund*. Formerly, copper sulphate and alum were extracted and sold separately at Rs. 14/- and Rs. 4/- per *maund* respectively. *Kasis*, ferrous sulphate or copperas, is also scraped from the walls of the mines and sold in the crude state without refining. It brings Re. 1/- per *maund*. The *kasis* efflorescence is grey, lighter and more powdery than that used in the preparation of *nila-thotha* which is bluish or greenish in colour.

A. M. Heron: "Geology of Western Jaipur," *Rec. Geol. Surv. Ind.*, Vol. LIV, pp. 386-387, (1923).

CORUNDUM

Corundum is the natural oxide of aluminium. Its transparent, coloured varieties form the ruby, sapphire and other precious stones. The opaque, dull kinds, on account of their great hardness, are used as abrasive materials. The mineral occurs in the Khasi Hills of Assam, associated with sillimanite ; at Pipra in the Rewa State of Central India ; in the Coimbatore, Anantapur, South Kanara and Salem districts of Madras and at many localities in Mysore. Sir Thomas Holland has shown how corundum has been used by Indian armourers and lapidaries for many generations, and how their requirements, have been met from a few comparatively rich deposits, though it is doubtful if these are worth working for export to-day, or will ever be able to stand against the competition of cheap imported abrasives. The production of corundum in India varies a great deal from year to year, thus in 1909, 814 cwts. were returned and in 1913, 8,924 cwts. During the war, the output rose to over 40,000 cwts. per annum, the greater part of which went to the United States of America and was used there for fine optical grinding. It is not certain, however, that much sillimanite was not included in this material. There is a constant demand for good crystalline corundum in the markets of the West, in spite of the ever-increasing use of artificial abrasives, and it is difficult to understand why corundum mining cannot be made a profitable enterprise in Southern India, as it has been in Madagascar and South Africa, where geological conditions are very similar.

C. S. Middlemiss : " Report on some trial excavations for Corundum near Palakod, Salem district," *Rec. Geol. Surv. Ind.*, Vol. XXX, pp. 118-122, (1897).

Sir T. H. Holland : " Corundum," A Manual of the Geology of India.—Economic Geology. 2nd Edit., Pt. 1, (1898).

K. P. Sinor : " Rewa State Corundum," *Bull. No. 1, Geological Dept., Rewa State*, (1923).

DIAMOND

All the older, famous diamonds of large size and enormous value, which are known by special names, are believed by those most competent to judge, to have come from India, and there are references in the classics of both East and West to the reputation of the country as a diamond-

producing region, yet the output of diamonds to-day is insignificant.

The earliest account of the diamond fields of India written as a result of personal observation, is that of Tavernier, published between 1665 and 1669. From the information given in this and other early writings, the ancient diamond fields have been grouped into three areas, which are all associated with pre-Cambrian rocks—the Kurnool system in the south and the Vindhyan system in the north. In the southern tract, including the districts of Anantapur, Bellary, Cuddapah, Kurnool, Kistna and Godaveri, the workings were mainly of an alluvial character ; but diamonds have been obtained from a conglomerate at the base of the Kurnools. The second area covers a portion of the Mahanadi valley and small stones have been obtained from alluvial deposits in the Sambalpur and Chanda districts. The third or central tract occupies a region some 60 miles long and 10 miles wide, with the Vindhyan conglomerates in the State of Panna in Bundelkhand in the centre. In this area the old diamond mining industry still lingers, the gems being derived partly from the conglomerate itself and partly from the alluvium to which it has given rise. A full account of the industry and of its possibilites has been given by the late Mr. Vredenburg whose work should be consulted for details.

During the five years ending 1918, the average annual value of the diamonds produced in Central India was only Rs. 18,240 (£1,216).

V. Ball: " A Manual of the Geology of India, Pt. III.—Economic Geology," pp. 1-50, (1881).

E. W. Vredenburg " Geology of the State of Panna, principally with reference to the Diamond-bearing Deposits." *Rec. Geol. Surv. Ind.*, Vol. XXXIII, pp. 261-314 (1906).

FLUORITE

Enquiries frequently reach the Geological Survey office regarding the occurrence of fluorite, or fluor spar, in India. The mineral is the fluoride of calcium, and it is consumed in large quantities by the basic, open-hearth process of steel manufacture, for it increases the fluidity of the slags and helps to remove objectionable elements like sulphur and phosphorus. It is known to occur at several localities in

India but only in insignificant quantities, and the requirements of the Indian steel industry are met from abroad. It is found at Berla, Kishangarh State, Rajputana, in a vein with quartz and calcite; in some of the wolfram-bearing quartz veins of South Tenasserim, in association with the arsenic ores of Chitral, and with the copper and lead ores of Sleemanabad, Jubbulpore district, Central Provinces. None of these occurrences, however, are, as far as is known, of any economic value.

GARNET (ABRASIVE)

Red and brown garnets are common minerals in the crystalline rocks of the Indian Peninsula and when they possess the necessary colour and are sufficiently free from flaws, they are often cut and sold as gems. Here, we shall only consider garnet as an abrasive material, an application which it owes to its hardness and fracture. Although garnet is so prevalent in India, there are few deposits of possible economic value known, and there is no regular trade in the mineral in spite of the demand for the proper kinds. They are used for making garnet paper, cloth and discs, being for these purposes crushed, classified and prepared in the same way as corundum or emery; the finished products being placed on the market in very similar forms. Abrasive garnet is employed mainly in the wood and leather trades for finishing purposes, and for these operations it is said to be indispensable, but the demand is a limited one and only capable of absorbing a few thousands of tons per annum. At present the market is supplied from the Adirondack region of the United States of America and from the Almeria province of Spain. In 1914, over 1,000 tons of garnet sand were returned as having been collected for abrasive purposes in the Tinnevelly district, Madras, but the fine, water-borne material, which has the edges of the mineral worn off, is not nearly so valuable as cleaned and graded garnet obtained *in situ* from rock. In 1920, 407 cwts. of garnet were won in Madras.

J. Coggin Brown: "Notes on Garnet," *Bull. Ind. Inds. Lab.*, No. 12, (1921).

GARNET (PRECIOUS)

Precious garnet is mined in certain of the Rajputana States. The stones come from the soil covering overlying hollows on the surface of the Aravalli schists, especially where these are traversed by granitic intrusions, and also from the beds of rivers which drain these rocks. Mining appears to be carried on intermittently and doubtless fluctuates directly with the local demand. The returns may show the production of a few tons for one year, and be blank for the next one. The finest stones come from the Sarwar district of Kishangarh, while Ajmere Merwara contributes smaller quantities. Recent examination has shown that the mines of Rajmahal in the Jaipur State have long been closed. The garnets from the other States of Rajputana are used by the jewellers of Jaipur, Delhi and elsewhere; they used to be exported to Europe, particularly to Austria, and they were obtainable recently in London. Practically the whole of the garnets worked in India belong to the variety known as almandite and are usually of a lustrous, deep red colour, often tinged with purple. Garnet of gem quality is found at many other localities, amongst which may be mentioned Gharibpet, Warangal district, Hyderabad, which was referred to by Voysey in 1833 and a neighbouring area, Khammamet, in the same district, from which 407 cwts. of garnet were exported to Europe in 1920.

Hessonite, or Cinnamon Stone, a yellow or yellowish-red garnet which closely resembles the true hyacinth or precious zircon, occurs in the Nilgiri Hills near Ootacamund, Madras, and in certain of the crystalline limestones of the Central Provinces. Spessartite, a garnet containing manganese is common in certain rocks of the Central Provinces. It varies in colour from a beautiful bright orange to a reddish-brown, but it is seldom free enough from flaws to be cut as a gem.

GLASS SAND

The early attempts to establish a glass industry in India appear to have failed largely owing to the absence of knowledge of sands of suitable quality. In more recent times however, good sands have been found in many parts of the country, notably at Mangal Hat and Patraghatta in the Rajmahal Hills, Bengal; at Loghra and Borgarh near Naini in the United Provinces; at Pedhauli and Sankheda in Baroda; in Bikanir and elsewhere. In many of these cases the material is in the form of a sandstone which has to be crushed and washed before use. The percentages of silica in typical samples from Patraghatta, Naini, Sankheda and Pedhauli were found on analysis to be 96·00, 98·95, 99·39 and 98·10 per cent. and the amounts of iron oxide, traces, 0·02, 0·04 and 0·04 per cent., respectively.

Glass works, using local sands or sandstones, have been established in many parts of India, amongst which may be mentioned, Allahabad and Firozabad (United Provinces), Ambala (Punjab), Telegaon (Berar), Jubbulpore (Central Provinces) and Madras, but the works situated in the Bombay Presidency have to obtain their sand from Naini, a distance of over 900 miles. During the war the glass industry received a great impetus, owing to the diminution of imports, and by 1921, no less than 32 concerns had established themselves, but owing to unsuitable locations to which raw materials and fuel have often to be transported hundreds of miles by rail, it is difficult to see how they can be profitably carried on in normal times. In a recent publication, Mr. Fox has devoted especial attention to the question of the selection of proper sites for glass works in India, and to the practical problems which have to be solved both in the design and management of such undertakings. Here, we are only concerned with one of the raw materials, the sand, and Mr Fox's conclusion after investigating the whole matter may be quoted :—" Within recent years special types of apparatus have been designed and used in crushing, grinding, washing, grading and drying sands for glass-making purposes. It is certain that by using some of these machines in India many local deposits of sand and sand-rock will be made available for use as good quality material. The price will, of course, be increased, but the market prices should still be less than those paid for similar sands in Europe, where prices f. o. r. at glass works range from 12 shillings to 40 shillings a ton in the case of natural sands, and up to 120 shillings or more for picked, crushed and graded quartz rock."

Twenty five years ago the annual imports of glass and glass-ware into India had a value of 66 lakhs of rupees (£440,000). Ten years later the value had gradually risen to over 135 lakhs (£900,000). In 1921 they were worth

over 343½ lakhs (£2,290,000). Surely there is scope for internal enterprise here.

C. S. Fox. "Notes on Glass Manufacture". *Bull. Ind. Inds. Lab.*, No. 29, (1923).

GOLD

The most important gold-producing region in India is the Kolar gold field of Mysore. Here, there is only one vein, averaging about 4 feet in thickness and profitable to work for a distance of little more than 4 miles, yet, from the commencement of European mining in 1882, to the end of 1921, it has yielded gold bullion of a total value of over £56,800,000, resulting in the payment of more than £20,000,000 in dividends to the shareholders of the companies concerned, and of some £3,000,000 in royalty to the Government of the State.

Attention was first drawn to the Kolar vein by the presence of ancient workings, which in some cases extend to a depth of 300 feet in it, and during the years 1878 to 1882 several large companies were formed to work concessions. All these were moribund by 1885, and it was only a dying effort by the Mysore mine in that year that disclosed the riches of the vein. At the present time there are five companies at work, finding employment for about 25,000 persons and disbursing annually over 11 lakhs of rupees in wages alone. Many of the workings are of great depth, attaining in 1921 a maximum of 4,890 feet vertically below the surface. Power is obtained from a hydro-electric installation on the Cauvery falls and transmitted to the mines over a double line, 92 miles long. Writing in 1916, Messrs. Smeeth and Iyengar of the Mysore Geological Survey state.—" 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..........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".

Hundreds of old workings have been found scattered over the surface of the Dharwar rocks in Mysore, but it is reported that the enormous amount of modern work which has been done on them, has proved conclusively that in the majority of instances they do not indicate the existence of valuable deposits immediately beneath them. Equally disappointing has been the investigation of the numerous quartz veins which traverse the schists and crop out at the surface. Smeeth and Iyengar sum the matter up as follows:— "We may take it as an almost universal rule that outcropping veins are valueless." After pointing out that it is possible that some zones of low grade ore may be found of sufficient extent, and under sufficiently favourable conditions, for cheap treatment to permit of their being worked, these writers conclude as follows :— "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".

Outside Mysore the only areas in which gold-bearing quartz veins have been mined on a large scale in recent years are those of Hutti in Hyderabad, of Dharwar in Bombay, of Anantapur in Madras and of Kyaukpazat in the Katha district of Burma. Mining commenced at Hutti in 1903 and was carried on profitably until 1916. For the five years ending 1918, an average annual output of 16,539 ozs. of bar gold, valued at over 9½ lakhs of rupees (£63,468) was obtained This fell to 10,647 ozs. in 1919 and to 12,390 ozs. in 1920. Since then operations have ceased. The gold-bearing quartz veins of the Dharwar district have been very thoroughly prospected and found to be unprofitable to work. The mines were abandoned in 1911. There are several large quartz veins in the Dharmavaram taluk of the Anantapur district, Madras, on which ancient gold mines are known to exist. A company was formed to open them up in 1905 and a great deal of development has been done; 2,532 ozs. of gold were obtained in 1910, and after that the output rose steadily to nearly 24,000 ozs. in 1915, since when there has been a regular decline, and in 1921 only 10,108 ozs. of fine gold, valued at £48,091 (Rs. 7,21,359), were returned. The Kyaukpazat mine in Upper Burma yielded gold worth £3,000 to £4,000 per annum for some years, reaching its maximum output of almost 2,000 ozs., valued at Rs. 1,14,090 (£7,606), in 1901, when the vein suddenly ended and the mine was closed down in 1903.

Alluvial gold is found in the sands of many Indian rivers, especially those of Burma, Assam, Bihar and Orissa, the Central provinces and Mysore. Regular returns of production are only forthcoming now from one or two districts in Burma and from the Punjab, and it is practically certain that these are incomplete. The indigenous alluvial miner is as often as not a cultivator who adds to his income by the speculative pastime of washing for gold, when the crops do not demand his immediate attention. The small quantities of the precious metal so obtained, in most cases probably find their way direct to the village goldsmith for the manufacture of trinkets. Dr. J. M. Maclaren, who made a searching investigation of the whole subject, concluded that in few countries is alluvial gold more widely distributed than it is in India, and in few countries also does it show less tendency to aggregation under the influence of running water. He has pointed out that wherever streams drain areas of ancient schistose rocks and possess the proper gradients for the deposition of gravel, they carry small amounts of alluvial gold. Such conditions apply in many parts of Mysore, Madras, Bombay, Hyderabad, Central India and Chota Nagpur, and to these we may add Burma, including the Shan States, parts of the upper Indus valley and certain tributaries of the Brahmaputra in Upper Assam, "but in no case," writes Dr. Maclaren, "so far as is yet known, are the gravels sufficiently rich to warrant European examination, though they in many places afford a few weeks' employment during the cold weather to the native washer, who is content to work for a return of 1½ to 2 pence per day." Maclaren's own investigations in the richest streams of Chota Nagpur, proved that the alluvial ground contained on the average about 1 to 1½ grains of gold per cubic yard, and that the six inches or so of the bottom gravel, which under normal circumstances would naturally be the richest, yielded not more than 2 grains per cubic yard. Such low values as these make it hopeless to expect any profitable return from large scale development.

In Chota Nagpur there are expanses of rock which are of Dharwar age, that is to say they belong to the same geological series, and are of much the same age as the auriferous rocks of Southern India. They resemble them further in being traversed by gold-bearing quartz veins. Many old workings have been met with along the outcrops and stones grooved by the crushing of the quartz have been found. Some of these ancient mines have been opened up and a certain amount of modern development has been carried out, but the results have been poor. A company was promoted a few years ago to mine gold-bearing quartz in Dhalbhum. This brought the gold output of Bihar and Orissa up to a maximum of 2,462 ozs. of gold, valued at Rs. 1,51,995 (£10,133), in 1917. Since then the concern has gone into liquidation.

Gold dredging was done on the upper reaches of the Irrawaddy, and on its two branches, the 'N-Maihka and the Malihka, above Myitkyina in Upper Burma, between 1903 and 1918. The average value of the gravels appeared to be about three grains per cubic yard. In all, 55,204 ozs. of gold, valued at Rs. 31,72,530 (£211,502) were obtained. Attempts have also been made to dredge in the Chindwin and Nam-ma rivers but without success; while systematic prospecting has usually shown, both in the Chindwin and other rivers, that although the gravels may furnish a source of income to the local washers, they are valueless for treatment on a large scale.

W. F. Smeeth and P. S. Iyengar: "Mineral Resources of Mysore." pp. 3-53, (1916).

J. M. Maclaren: "The Auriferous Deposits of India," *Min. Journ.*, LXXXIV, pp. 198–199, 228–229, 269–270, (1908).

GRAPHITE

In recent years small quantities of graphite have been obtained from the Kalahandi and Patna States of Bihar and Orissa and from Ajmere-Merwara in Rajputana. The graphite deposits of Travancore occur in similar rocks to those of Ceylon which have produced very large quantities of graphite. The average output from Travancore used to be

about 13,000 tons annually, but the mines were closed down in 1912, as increasing depth made it unprofitable to work them. Small occurrences of the mineral have been recorded from other places. The war stimulated production once more and a maximum of 1,318 tons was obtained in 1916, most of which came from Rajputana, but by 1921 the figures were down to 25 tons again.

The prevailing rocks of the southern portion of Orissa are known as khondalites and they contain graphite as an essential constituent. It is not surprising therefore to find the graphite concentrated sometimes into bands, veins and pockets, in the States of Kalahandi and Patna, or in the Vizagapatam district, into which the khondalites extend. Dr. Fermor has given his views on this subject in the following words:—"Owing possibly to the comparatively inaccessible and undeveloped character of this part of India, only a very few deposits of graphite of very moderate value have, however, hitherto been discovered, in the States of Kalahandi and Patna with recorded occurrences in the States of Athmallik and Sonpur, but other discoveries must be expected in the future when this tract becomes better known".

C. S. Middlemiss has described a large, rather low grade deposit of amorphous graphite occurring near Braripura, Uri Tehsil, Kashmir, regarding which he remarks,—"there may well be doubts as to its successful utilisation for economic purposes."

C. S. Middlemiss: "The Graphite Deposit of Braripura, Uri Tehsil, Kashmir," Srinagar, (1922).

L. L. Fermor: "Mineral Resources of Bihar and Orissa." *Rec. Geol. Surv. Ind.*, Vol. LIII, p. 270, (1922).

GYPSUM

Gypsum, the sulphate of calcium, occurs abundantly in some parts of India. Beds of the impure mineral of considerable extent, occupy the basins of dessicated salt lakes among the sand hills of Rajputana, especially in Marwara and Bikanir, and have supplied the greater part of the output for years. Gypsum also exists in enormous quantities in massive beds of considerable purity in association with the Salt Marl, along the southern base of the Salt Range in the Jhelum, Shahpur and Mianwali districts of the Punjab, but very little use has been made of it. There are large deposits in the Kohat and Dera Ismail Khan districts of the North-West Frontier Province and in Cutch and Sind. Other large deposits believed to contain some hundreds of millions of tons of gypsum occur in the Uri Tehsil of Kashmir. The average annual production for the five years ending 1918 was 18,857 tons, valued at Rs. 14,625 (£975), and since then there has been a large increase, the record figure of 33,801 tons, valued at Rs. 34,018 (£2,267) being reached in 1921.

IOLITE

Iolite or cordierite, a mineral which forms the gem-stone known to jewellers as the lynx or water sapphire, occurs in violet patches and spots in a granite dyke near Thiruvella, Travancore. It is also found near Kiranur and Udaiyapatti, in the Kadavur estate of Trichinopoly district, Madras. As there are old pits in this vicinity, it seems that the mineral was once sought for. Polished iolite has been obtained associated with remains of the early Buddhist period in India.

IRON

The knowledge of iron metallurgy in India possesses a high antiquity. The rusted implements found in the urn burials of a very early period prove this. The iron pillar at Delhi, which weighs over 6 tons, carries the epitaph of Chandragupta II, composed in or about 415 A. D. The manufacture of "wootz" or Indian steel, in small clay crucibles, is also a process which has been known for centuries. Until it practically succumbed in comparatively recent times, before the competition of imported metal, the indigenous iron industry was both wide-spread and prosperous and there is said to be hardly a district in the Empire from the extreme south to the Himalayas, or from Baluchistan to the Shan States, with the exception of the great alluvial plains, where heaps of old iron slags have not been found. It does not follow, however, that ores suitable either in quality or quantity for the needs of a modern blast furnace occur in all these places.

Failure attended all the early efforts to manufacture iron on a large scale in India. In 1830, works were established

at Porto Novo in the South Arcot district, Madras, and a few years later at Trinomali in the same district and at Beypore on the Malabar coast, but by 1867 they had closed down. In Bengal, the history of the industry starts in 1777, but by 1779 the first speculation was relinquished. Again, in 1855, furnaces were erected at Mahomed Bazaar in Birbhum, only to be closed down a few years later. Full particulars of these and other early schemes cannot be given here, interesting though they are. The Barakar Iron Works Co., started operations in 1874, later it became the Bengal Iron and Steel Co. Ltd., the forerunner of the Bengal Iron Co. Ltd. of to-day. The successful results of this concern in the later stages of its career as the Bengal Iron and Steel Co. Ltd., mark the establishment of India's iron industry on permanent foundations. The next stage was the inauguration of the Tata Iron and Steel Co. Ltd., the two original blast furnaces of which were blown in 1911 and 1912 respectively. In 1912, India's domestic production of iron amounted to about 50,000 tons per annum, but her imports of heavy iron and steel goods totalled upwards of 700,000 tons. A consideration of all the available statistics, leads to the conclusion that during a series of years in which her industrial development was retarded by the war, India's annual consumption was in the neighbourhood of one million tons per annum. Adding the values of the more finished articles such as machinery and hardware to the heavy goods such as rails, beams and girders, we find the total value of the imported articles to be follows :—

Year			Value of imported iron and steel goods
1912	...	...	£16,000,000
1914	...	...	£27,000,000
1920	...	...	£25,000,000

The manufacture and rolling of Indian steel was successfully established about the end of 1913. Before the war, Indian pig iron had been shipped to Burma, the Straits Settlements, Ceylon, Java, Manchuria, China, Japan, Australia, New Zealand, the United States and South America. During the war, export was prohibited, and the whole output of Indian steel rails was taken for use in

Mesopotamia, East Africa and Palestine, a portion being shipped as far as Salonica. Shell steel was supplied to the Indian munitions works and both iron-producing companies made ferro-manganese on a large scale. Post-war conditions have prevented the resumption of the export trade on its former scale, but it is slowly improving and the latest available returns show that it is mainly with Japan.

Indian iron ores are classified as follows :—

1 Banded rocks composed of iron and quartz associated with other rocks of Dharwar age. In them the iron ore is sometimes concentrated into ore bodies of great size. These deposits furnish the ores which are being smelted to-day. The better known examples are in Singhbhum and the feudatory States of Orissa, in the Chanda, Drug and other districts of the Central Provinces; in the Kadur district of Mysore and in Goa and Ratnagiri.

2 Bands and nodules of clay ironstone found in certain rocks in the coalfields of Bengal, Bihar and Orissa. They supplied the ores used in the early days of iron smelting in Bengal but they are not used to-day.

3 Surface ores formed by the segregation of iron oxides in a tropical climate. These were employed in the distant past by the old Indian iron makers. Their application now-a-days is strictly confined to very special purposes.

The huge iron ore deposits of Singbhum and the Keonjhar, Bonai and Mayurbhanj States of Orissa, lie some 150 to 200 miles west of Calcutta, and in the words of Mr. Cecil Jones of the Geological Survey of India, who is engaged in their systematic investigation, "are remarkable for the enormous quantities of extremely rich ore they contain, and will undoubtedly prove to be amongst the largest and richest in the world." The minimum quantities estimated up to the present, of ore containing not less than 60 per cent. of iron, are 2,832,000,000 tons, on a conservative basis. The ore usually occurs at or near the tops of hills and the most important hill-range has a length of about 30 miles. It rises 1,500 feet above the plains, and iron-ore averaging over 60 per cent. of iron occurs for practically the whole length.

The Bengal Iron Co. Ltd. first started mining operations in 1910, and a light railway runs from the main line of the Bengal Nagpur Railway to their concessions. During the past three years much prospecting has been done by other firms, and the Tata Iron and Steel Co. Ltd., the Indian Iron and Steel Co. Ltd., Messers Bird and Co. Ltd., and Messers Villiers Ltd., have all been granted, or have applied for, mining leases. A branch line of the Bengal Nagpur Railway is under construction to give access to the eastern portions of the iron-fields.

Other important areas can only be mentioned in the briefest possible manner. In the Chanda district of the Central Provinces, there are at least ten separate deposits of iron ore and some of them are of large size. In the Drug district of the Central Provinces, the iron ores form hillocks rising above the level of the surrounding country, and it is believed that these deposits extend into Bastar State. The Bababudan Hills, in the Kadur district of Mysore, contain many millions of tons of ore. The residual, surface deposits of iron ore which occur near Wetwin and other places in the Northern Shan States, Burma, are mined for use as a flux in lead-smelting operations.

In addition to the two producing companies already mentioned, the Indian Iron and Steel Co. Ltd. commenced to manufacture iron at the Hirapur works near Asansol in 1922, while the charcoal-using blast furnaces of the Mysore State were blown in early in 1923.

This short note would be incomplete without reference to some of the subsidiary industries which are springing up, and which depend on the producers of iron and steel for the bulk of their raw material. Works are either finished or under construction for the manufacture of machinery of all kinds, especially those forms used so extensively in India's mills, of agricultural implements, enamelled wares, steel wire products, metal pipes, tin plates, electric cables, railway wagons and locomotives. Foundry-made cast iron products such as railway sleepers and chairs, axle boxes, pipes and miscellaneous castings have of course been manufactured in India for many years.

Output of Iron ore and its Products 1917–1922 (in tons)

	1917	1918	1919	1920	1921	1922
Iron Ore	413,272	492,669	563,750	558,005	942,084	625,274
Pig Iron	248,122	247,412	317,333	311,256	367,986	366,613
Steel	111,027	130,043	134,061	113,222	125,336	111,500
Ferro-Manganese	3,732	12,114	7,382	1,183	3,076	1,810

J. Coggin Brown: "The Iron and Steel Industry of India," *Min. Mag.*, Vol. XXIV, pp. 339-347; Vol. XXV, pp. 11-19, (1921).
H. Cecil Jones: "The Iron Ores of Singhbhum and Orissa," *Rec. Geol. Surv. Ind.*, Vol. LIV, pp. 203-214, (1923).

JADESTONE

Although it is generally agreed that Burmese jadestone belongs to the mineral species known as jadeite, the means of distinguishing it from jade proper and from other groups of minerals, including bowenite, and some varieties of serpentine are not always easy. Prehistoric implements of jade and jadeite are well known, the latter being common in parts of China, but the possibility of many of them being modern copies of ancient prototypes should not be overlooked, as the stone is still believed to possess magical properties as a charm by Eastern races.

Although objects fashioned from Burmese jadeite, such as strings of beads, plaques for pendants and small carvings, are familiar objects in the jewellers' shops of London, Paris and New York, the real market for the stone is, as it has been for centuries, in China, which the mineral reaches by sea from Rangoon to Canton, or overland through Têngyüeh. It is noteworthy that conditions of general prosperity in China stimulate jadeite-mining in Burma, while famine, pestilence and civil war make it stagnant.

Jadeite is worked at Mamon, Hweka and Tawmaw in the Mogaung sub-division of the Myitkyina district, Upper Burma. It is obtained *in situ* from a serpentine dyke and as boulders from alluvial deposits. The royalty on the stone

is collected under a pernicious system of "farming out", the official returns of production are quite misleading, for large quantities are undoubtedly smuggled over the Burma China frontier to Têngyüeh. The official export returns show an annual average of 4,651 cwts. for the five years ending 1918-19, the value being £74,498 or £16.02 per cwt. There can be no doubt that these declared values are very much under-estimated.

The commonest colours assumed by Burmese jadeite are a brilliant white, spotted marbled-white, greyish, pale greenish-white, or the most delicate, translucent, purplish-white back-ground, flecked or mottled with very vivid apple-green. Emerald green, and dark green shades are not so common. Pale amethystine and red tints are rare. The translucent white material with bright green spots is perhaps the most highly prized.

KYANITE

Kyanite is a blue mineral varying from a deep cornflower shade to a pale sky-blue. When quite transparent, which is unfortunately not often its condition, it forms, properly cut, a very pretty gem. According to Max Bauer, the well-known authority on precious stones, the best crystals are said to come from unknown localities in India—a country in which kyanite is more extensively used than in Europe. "There is no doubt", writes Bauer, "that kyanite occurs at many places in India, but it has been suggested that the stones worn in that country have all come from Europe." The suggestion is probably incorrect, for blue kyanite is obtainable at many places in the Archaean formations of India. It is particularly abundant in the schists and granites of Bashahr in the Himalaya, where the intense blue colour of the crystals has often led to them being mistaken for sapphires. One of the better authenticated localities for gem kyanite is Narnaul in the Patiala State, where it is used by the local jewellers.

Max Bauer: "Precious Stones". English translation by L. J. Spencer, p. 415.

LAPIS LAZULI

India merely acts as the mart for the lapis lazuli of Badak-shan, but there is one locality where the mineral occurs sparingly which seems to have escaped the notice of previous commentators on Indian gems, though the occurrence of lazulite has been known there for some time, and that is Mogok, the centre of the ruby mining tract of Upper Burma. Beads of this magnificent, azure-blue stone are obtainable occasionally in Mandalay and Rangoon.

LEAD

Although galena, the sulphide of lead, has been found at a large number of places in India and Burma, the story of the rise and development of the lead, silver and zinc industries in India, is, for all practical purposes, the history of the opening up of the great ore deposit of Bawdwin in the Northern Shan States and of the expansion of mining and metallurgical operations there. The lead-silver-zinc ores were mined by the Chinese from the early part of the fourteenth century until the middle of the eighteenth century. They extracted the lead-silver ores from the upper part of the deposit and treated them for silver on the spot, leaving great heaps of rich, lead-bearing slags which furnished large quantities of lead for some years, from 1909 onwards until they were exhausted. European exploitation dates from 1902; the early ventures were not successful and in 1914, the control of the mine passed into the hands of the present lessees, the Burma Corporation Ltd. Underground exploration below the level of the old Chinese workings has proved the existence of an ore channel at least 8,000 feet long and 400 to 500 feet wide. Within this zone there are two ore bodies of major importance. The first, known as the "Chinaman," is a huge, lenticular replacement with a core of practically pure sulphides of lead and zinc. It is known to contain nearly 5 millions of tons of ore averaging 27·6 per cent. lead, 19·0 per cent. zinc, 0·5 per cent. copper and 25 ozs. of silver per ton of lead. It should be pointed out that the ore body is not yet fully explored and that the estimate given here does not include ore containing under 20 per cent combined lead and zinc, though very large amounts of such material are known to exist. Over half a million tons of high grade ore have been taken from this ore body so far. The second ore body is known as the "Shan," and consists of a mixture of the sulphides of lead and zinc with larger

quantities of copper. A recent estimate of the proved and probable ore in the Shan body places the total at 570,000 tons averaging 17 per cent. lead, 11 per cent. zinc, 6 per cent. copper and 19·3 ozs. of silver per ton of lead. The mines are connected with the Burma Railways by a narrow gauge line 50 miles long which passes through Nam Tu, a few miles from Bawdwin, where the head offices and smelters of the Corporation are situated. There is a large concentrating plant there also, fitted with the most up to date devices, four blast furnaces, and a refinery in which the silver is recovered. Hydro-electric power is derived from the Mansam falls over a transmission line about 20 miles long.

In 1921, 33,717 tons of lead valued at Rs. 1,17,46,967 (£783,131) were extracted. The apparent consumption of lead in India is about 14,000 tons per annum, so that there is far more than sufficient lead available in the country to meet its needs. As regards the future, the ore reserves of the Bawdwin mine, actual and probable, are big enough to make it safe to predict that Burma is likely to be before long, the chief new factor in the world's production of lead.

J. Coggin Brown: "Geology and Ore Deposits of the Bawdwin Mines," *Rec. Geol Surv. Ind.*, Vol. XLVIII, pp. 121–178, (1917).

LIMESTONE

Limestones used as building stones and for cement manufacture have been considered separately. Here their use as a source of lime will be dealt with, and for this purpose the quantities available are to all intents and purposes unlimited, though naturally, only those deposits are worked which are most conveniently situated from the point of view of transport, or for some other special local reason. Amongst many others the following merit special mention :—

(a) The limestones of the Upper Vindhyan series worked near Sutna in Rewa State by the Sutna Stone & Lime Co., Ld.

(b) Those of the Lower Vindhyan series worked near Katni by Messrs. Cook & Sons and others; near Rohtasgarh and Dehri-on-Sone by several companies, including the Kalyanpur Lime Works, Ld.; the Kachwar Lime & Stone Co. Ld; the Shahabad Lime Co.

(c) Those worked in the Cuddapah series at Bisra and Rourkela in Gangpur State by the Bisra Stone & Lime Co., Ltd.

The Sylhet Lime Co., Ltd. draws its raw material from the Nummulitic limestones of the southern scarps of the Khasi and Jaintia Hills. Vast quantities of limestone are available in many other parts of India, but the subject is too large for a summary of them to be given here.

A very widespread source of lime is the material known as ***kankar*** or ***gutin***, which is a nodular, concretionary form of impure calcium carbonate, often contaminated with much argillaceous and siliceous matter. It is very generally distributed throughout the plains of India, especially in the older alluvium of large rivers like the Ganges. It is used in road-making operations, and burnt to form lime, mortar and crude hydraulic cements.

LITHOGRAPHIC STONE

Writing in 1881, on the general characters of lithographic stones, Mr. V. Ball remarked,—"Limestones suitable for lithographic purposes are not of wide distribution, the combination of qualities requisite are not often found united". He shows how the applicability of the lithographic process to the reproduction of the vernacular writing, where types were not available, led to its extension and wide adoption all over the country, while the price of stones imported from Europe early led to trials being made of stones of indigenous origin. Ball quotes a number of localities where limestones more or less suitable may be obtained, and a later list is given in La Touche's Bibliography. From time to time these trials have been repeated and during the War, when the supply of German stones entirely ceased, experiments with various kinds of Indian materials were made. Although some of these proved suitable for the rougher kinds of work, on the whole they do not approach the finer qualities of the German and Austrian stones, and it is highly probable that as these are now obtainable again, they have resumed their old position in the Indian market. Although the number of presses using lithographic stones in India is undoubtedly large, the life of a good stone is a long one, while the introduction of rotary litho-presses using zinc plates instead of stones, tends to further decrease the use of the natural material.

MAGNESIUM SALTS

Magnesium chloride and its sulphate occur with sodium chloride and other salts in sea water, and in the manufacture of common salt from this source they become concentrated in the "bitterns", as the residual mother liquor which is left in the "pans" after the salt has crystallized out is called. Attempts have been made from time to time to make magnesium sulphate (Epsom Salts) on a large scale from bitterns, and the extraction of bromides has also been investigated, but so far without commercial success. At Kharaghoda, however, in the Rann of Cutch, Bombay, magnesium chloride is manufactured. At this place there are important salt works under the control of the Government of Bombay, which have been in operation for thirtysix years and now produce about 146,000 tons of common salt annually. The brine is obtained from wells and contains the common constituents of sea water in a more highly concentrated form than they are found in the ocean.

Magnesium chloride is used as a sizing agent in the textile industry, and it has been estimated that the total annual requirements of the country are at present about 4,500 tons per annum, a demand which was almost entirely satisfied from the Stassfurt region of Germany before the war. The cessation of these supplies led to the formation of the Pioneer Magnesia Works which now manufacture commercial magnesium chloride at Kharaghoda. In the fiscal years 1914-15, the imports of this salt amounted to 2,705 tons, valued at Rs.3,00,570 (£20,038), and in 1921–22 to 2,330 tons, valued at Rs.4,49,680 (£29,979). The sales of the Kharaghoda product have increased from 838 tons in 1916-17 to 1,099 tons in 1921-22. In 1918-19, 1,970 tons were sold. There is also a considerable production of magnesium chloride at Dhrangadra. The manufacturing process is described in a paper by Mr. Lalkaka which has been freely used in the preparation of this note.

B. S. Lalkaka: "Magnesium chloride manufacture and the Pioneer Magnesia Works". *Journ. Ind. Inds. Lab.*, Vol. II, pp. 435-443 (1922).

MAGNESITE

The most important magnesite deposits of India are those of the Chalk Hills, situated between the town of Salem and the Shevaroy Hills in Madras. Here, great intrusive masses of olivine-bearing rocks have become serpentinised and traversed, over an area of about 4½ square miles, by an intricate network of magnesite veins. The reserves of the mineral are said to be practically unlimited. It is won by open quarrying, and part of it is lightly calcined on the spot before being railed to Madras for export. Large deposits of the mineral also occur at Dod Kanya and Dod Katur, in the Mysore and Hassan districts of Mysore. At the former locality, a lens of serpentine about ¾ of a mile long and ¼ of a mile wide, is traversed by veins of the mineral. The reserves are believed to amount to several hundreds of thousands of tons. Many other occurrences are known, especially in Southern India. Magnesite is the source of magnesia, the main use of which is as a refractory lining for steel furnaces. It is also the chief component of the "oxy-chloride" or Sorel cements, used in the manufacture of patent floorings, artificial stone, etc. The average annual production of magnesite in India for the years 1914 to 1918 was 10,165 tons, valued at Rs. 1,13,520 (£7,568); by 1921 the total had risen to 20,017 tons, valued at Rs. 2,34,474 (£15,632).

C. S. Middlemiss: "Report on the Magnesite areas of the Chalk Hills, etc., near Salem." *Agric. Ledger*, III, No. 15, pp. 1-11, (1896).

H. H. Dains: "The Indian Magnesite Industry." *Journ. Soc. Chem. Ind.*, Vol. XXVIII, pp. 503-505 (1909).

MANGANESE

The manganese industry dates from 1891, when a Company was formed to open up the deposits of the Vizagapatam district of Madras. In 1899, attention was first directed to the Nagpur district, later on to discoveries in the Bhandara, Balaghat and Chindwara districts of the Central Provinces, and later still to deposits in Central India, the Bombay Presidency and Mysore. Rapid development followed, and a maximum output of 902,291 tons was reached in 1907. In 1908, India displaced Russia from the head of the list of the world's producers, though in 1912 and 1913 she gave way again, but after 1914 Russian exports practically ceased. In

spite of the war, the Indian production for the five years ending 1918, averaged 577,457 tons annually. Production since that date is shown in the following table :—

Production of Manganese Ores in India.

Year	Tons	Value £ o. b. at Indian ports
1919	537,995	£1,546,330
1920	736,439	3,586,072
1921	679,286	1,537,068

With the exception of the small quantities of ore consumed in the manufacture of ferro-manganese in the country, most of the material is exported, mainly through Bombay and Calcutta. The following table shows its destinations :—

Distribution of Exports of Manganese Ores in 1919, 1920 & 1921.

	1919 tons	1920 tons	1921 tons
United Kingdom	224,157	350,383	96,759
Belgium	76,259	164,832	228,764
France	52,300	70,091	79,855
Italy	3,250	15,300	9,600
Japan	1,690	nil	2,250
United States of America	12,800	105,600	86,360
Other Countries	3	4,650	36,301
TOTAL	370,459	710,856	539,889

The great decrease in exports to the United Kingdom in 1921 was due to the temporary stagnation of the iron and steel industries there. Part of the large exports to Belgium probably found their way to Germany.

The development of the Bessemer and open-hearth processes for making steel about 1870 created the demand for the manganese alloys, and the steel industry now consumes at least 90 per cent. of the world's output of manganese ores in connection with these processes. The ores are also used in the heavy chemical, electrical and glass industries.

The reader desirous of obtaining detailed information regarding Indian manganese mines should consult Dr.

Fermor's exhaustive memoir and the same author's more recent writings in the Quinquennial Reviews of Mineral Production in India. Dr. Fermor has divided the deposits of economic value into the following three main groups:—

A. Those associated with a series of manganiferous intrusive rocks known as the *kodurite* series. Found in Madras:— Ganjam, *Vizagapatam*.

B. Those associated with a manganiferous type of rock of Dharwar age known as *gondite*. Found in:—
Bihar and Orissa:—*Gangpur*.
Bombay:—Narukot, Panch Mahals, *Chhota Udaipur*.
Central India:—*Jhabua*.
Central Provinces:—*Balaghat*, *Bhandara*, *Chindwara*, *Nagpur* and Seoni.

C. Those occuring as *lateritoid* replacement masses on the outcrops of Dharwar rocks. Found in:—
Bihar and Orissa:—*Singhbhum*.
Bombay:—Dharwar, North Kanara, Ratnagiri.
Central Provinces:—*Jubbulpore*.
Goa.
Madras:—*Bellary*, *Sandur*.
Mysore:—*Chitaldrug*, *Kadur*, *Shimoga*, *Tumkur*.

(Italics denote that ore has been worked for export).

The ores of the Vizagapatam district are composed mainly of psilomelane with subordinate amounts of pyrolusite, braunite and other minerals. They are usually of second and lower grade qualities. The typical ores of the Nagpur-Balaghat area of the Central Provinces are hard, fine-grained mixtures of braunite and psilomelane. The ores exported from the Central Provinces are nearly all of the first grade with a high manganese content. The lateritoid ores contain manganese minerals such as pyrolusite, psilomelane, wad, etc., and iron-bearing minerals like limonite and earthy hematite. They consist mainly of second grade material.

Manganese ore deposits both of classes A and B often attain a great size. The Garbham occurrence is some 1,600 feet long and 167 feet wide, at its thickest section. The Balaghat deposit is 1¾ miles long; the one at Manegaon in the Nagpur district is 1¼ miles long, whilst the band running through Jamrapani, Thirori and Ponia, in the Balaghat

district, is exposed more or less continuously for nearly 6 miles.

The outlook for the Indian manganese trade is encouraging, for with the present revival of the iron and steel industries in Europe and elsewhere, there is sure to be an increasing demand for the ore. It is not anticipated that the domestic resources of the United States of America, which were so extensively drawn on during the war, will come into serious competition with the Indian ones, and it is reported on good authority that the Brazilian supplies are insufficient to meet the probable total needs of America in the future. It is impossible to foretell whether the Russian trade will flow along its old channels, but, in any case, India has no more cause for apprehension from this quarter now than she has had in the past. India, however, will have to face the competition of the Gold Coast, a comparatively new comer into the manganese ore markets of the world, but this is not likely to be keen until proper transport and shipping facilities have been provided there.

L. L. Fermor: "The Manganese Ore Deposits of India." *Mem. Geol. Surv. Ind.*, Vol. XXXVII (1909).

MICA

For many years India has been the leading producer of mica, with an output of more than three-fifths of the world's total. The great mica belt of Bihar is a strip of country some 12 miles broad and 60 to 70 miles long, composed of crystalline rocks with intruded pegmatites, which runs obliquely across the junctions of the Monghyr, Hazaribagh and Gya districts from Jhaja to Champaran. Mica mining appears to have been carried on as a serious business for about 50 years, and was of course greatly stimulated by the war; although there are a few well-equipped properties, many of the workings are of a primitive character, and are merely narrow winding holes in the pegmatite veins, following on from one "book" of mica to the next.

There is another important mica-producing area in the Nellore district of the Madras Presidency. The plains of the district between the Veligonda range and the sea, and between latitudes 14° and 15°, are occupied by crystalline rocks, the eastern portions of which are traversed by sheets and lenses of coarse mica-bearing pegmatite. There are four main zones, named after the towns of Gudur, Rapur, Atmakur and Kavali. The principal mines are in the Rapur zone. In Nellore, it is customary to attack the pegmatites by means of large open quarries.

Mica has also been obtained from the Salem and Malabar districts of Madras, from Ajmere-Merwara and other parts of Rajputana, while Travancore yields the soft, amber-coloured variety known as phlogopite, as distinct from the muscovite mica of the other regions.

Mica finds its chief use in the electrical industry as an insulating medium. For this and other purposes, its perfect cleavage, flexibility, toughness, non-conductivity of electricity and heat, and its resistance to high temperatures and decomposition make it indispensable. The enormous expansion of electrical engineering has depended on the unique combination of properties possessed by mica, and they were also of the greatest importance during the war, for the developments of wireless telegraphy, of aeronautical science and of motor transport would have been impossible without them.

The commercial value of mica is greatly affected by its cleavage, *i.e.*, the ease with which it can be split into flat sheets free from irregularities and giving a perfect reflection, by its hardness and flexibility, by its colour, by its freedom from specks, stains, inclusions, etc., and last, but by no means least, by the size of the sheets themselves. On the London market nine quality grades are recognised and nine size grades, varying from the smallest, known as "No. 6", from 1 to 2¾ square inches in area to "extra-special", which measures from 60 to 70 square inches. Mica splittings are made by separating the small sizes of block mica into the thinnest possible films. In India this operation is performed by women and children, who attain a remarkable dexterity at the process. The splittings are used in the manufacture of micanite. The thin films, generally about ·001 inch in thickness, are assembled into a sheet. The binding material, usually a solution of shellac in spirit, is then applied. Another layer of films is added and more of the binding

agent, and so on, until, after heat and compression, a mica board of the required thickness, is obtained.

For the pre-war quinquennial period ending 1913-14, the average annual exports of mica from India were 45,381 cwts. valued at Rs. 33,06,210 (£220,414). The United Kingdom took 55 per cent. of this, and Germany and the United States 16 per cent. each. During the next quinquennium, the average annual exports were 49,586 cwts., valued at Rs. 57,46,210 (£383,014). Since then the exports have been as follows:—

Exports of Mica 1919-20 to 1921-22.

1919-20.	60,648	cwts.	valued	at	Rs.	86,16,640	(£574,443)
1920-21.	71,276	„	„	„	„	1,01,13,810	(£674,254)
1921-22.	27,132	„	„	„	„	63,34,063	(£422,271)

Sir T. H. Holland: "The Mica Deposits of India". *Mem. Geol. Surv. Ind.*, Vol. XXXIV (1902).

J. Coggin Brown: "Notes on Mica". *Bull. Ind. Inds. Lab.*, No. 15 (1921).

MINERAL COLOURS

The mineral colours are usually divided into three groups as follows:—

(1) Natural mineral pigments.
(2) Pigments made from ores or ore residues.
(3) Chemically manufactured pigments.

Group 1, the only one to be considered here, includes the ochres, oxides, umbers, siennas, ground slate and shale. Many other minerals are used in the paint industry, such as asbestos, barytes, kaolin, clays, chalk, graphite, magnesite, mica, steatite, etc. Notes on these will be found elsewhere. The most important Indian colours are the ochres and oxides. The ochres are mixtures of ferric hydroxides with sand, clay and other substances, and are exceedingly permanent colours, varying from a brilliant, lemon yellow to a rich, golden colour. The oxides owe their value to ferric oxide and possess various shades of red, purplish-red and brown.

The abundant occurrences of earthy iron ores and of laterites in India lead to the presence of ochres and oxides in very many localities, the more important ones being in the Feudatory States of Orissa; the Kaimur plateau and the States of Central India; the Chanda, Jubbulpore and Nagpur districts of the Central Provinces and numerous localities in Madras and Mysore. C. S. Middlemiss has recently described the ochre beds of the Uri Tehsil, Kashmir, where upwards of 200,000 tons of ochres of good quality ranging from pale yellows through Indian yellow and Venetian red to deep browns, are believed to be available.

At one time India supplied large quantities of excellent yellow ochres to the United Kingdom, but the trade has ceased. The well-known "Indian Red", however, probably came from the Persian Gulf. Very little attention has been paid in this country to the possibility of the occurrence of brown earths of the sienna and umber groups, which are comparatively valuable products and may occur in association with manganese ores. For the five years ending 1918 the average annual production of ochres and oxides was 2,637 tons, valued at Rs.17,025 (£1,135). In 1921 over 5,800 tons were won, worth more than Rs.31,500 (£2,100); the greater part of this came from Central India and Gwalior.

J. Coggin Brown: "Notes on Mineral Colours", *Bull. Ind. Inds. Lab.*, No. 21, (1922).

C. S. Middlemiss: "Ochre Deposits of Nur Khwah, Rata Sar and Jhuggi in the Jhelum Valley, Uri Tehsil, Kashmir." Srinagar, (1922).

MINERAL WATERS

The following note on mineral waters was written by Sir Thomas Holland 15 years ago, but it applies with equal force to-day, and is therefore quoted in full:—

"One curious feature in connection with Indian minerals is the neglect of our numerous hot and mineral springs. To what extent the value of these is purely fanciful is a matter of small concern for the time being; for whether they have the medicinal properties claimed for them or not, there is no doubt that well-advertised mineral waters have an economic value, and numerous varieties from Europe and Japan are scattered over India, and brought to the continual notice of the travelling public in all railway refreshment rooms. Natives of India have for many ages recognised a value in mineral waters and in the hot springs which are often charged with more than usual quantities of mineral matter. In many cases, these, like most unusual natural phenomena, have become sacred to the Hindus, and have consequently become places of resort for pilgrims from great distances. Of instances of this sort may be mentioned the hot springs at Manikarn in Kulu, where the pilgrims cook their rice in the hot springs emerging in the shingle beds close to the ice-cold stream of the Parbatti river. The hot water is also led into the neighbouring temple and rest-house for baths, being supposed to be of value for rheumatism. At Lasundra in the Kaira district, and at Vajrabai in the Thana district, Bombay Presidency, springs of sulphurous water, having a temperature of 115°F, are also resorted to by Hindu pilgrims. Hot springs, often sulphurous, are common throughout the Tertiary areas of Sind and Baluchistan on one side, and of Assam and Burma on the other side of India, the distribution being similar to the distribution of petroleum. Other springs occur along the foot-hills of the Himalayas, in the Kharakpur hills, etc., sufficiently well distributed to permit of easy transport."

The springs of Jawalamukhi in the Kangra district contain bromide and iodide of sodium and potassium, while those of Tuwa in the Panch Mahals of Bombay are highly radioactive. The waters of a spring at Sipri, Gwalior, are bottled and marketed by a Bombay firm, while those of Sitakhund in the Kharakhpur hills are still turned to account by a well-known Calcutta house.

Sir T. H. Holland: "Sketch of the Mineral Resources of India", pp. 52-53, (1908).

MOLYBDENUM

Molybdenite, the disulphide of molybdenum, is used in the preparation of the metal from which it derives its name. The latter, and its alloy, ferro-molybdenum, are used in conjunction with other metals, such as chromium, nickel, tungsten and vanadium, to impart desirable properties to special steels; thus they may be used to increase the tensile strength, elasticity, toughness, hardness, and resistance to shock, fatigue and exposure. Such steels are used for big guns, rifle barrels, propeller and crank shafts, armour-piercing shells, light armour plate, and so on.

Molybdenite has been found in small quantities at many places in India, including a pegmatite at Kunnavaram, Godaveri Agency, Madras, and under similar conditions in the Tovala taluk of Travancore, and near Kishangarh, Rajputana. It has also been noticed in some of the metamorphic rocks of Chota Nagpur. The most important occurrences are in Burma, in association with the wolfram and tin-stone bearing veins of that Province. It has been found at Byingyi, Yamethin district, and at many localities in Tavoy and Mergui. Mines where it is comparatively abundant include Sonsinpaya, Wagon North, Kadantaung, Thingandon and Widnes, all in Tavoy district.

Small parcels of the ore have been shipped from Burma occasionally, the largest being one of 27 cwts., valued at Rs.9,390 in 1917. Owing to primitive mining methods and the absence of proper machines for concentration, the industry had not advanced beyond an early experimental stage in Burma, where it was caught by the general slump which set in after the Armistice. The deposits have not yet received the attention they deserve, and molybdenite may some day prove a valuable by-product of tin and wolfram mining.

MONAZITE

Monazite, a phosphate of the rare earths of the cerium group, is widely distributed in India, but the only deposits of commercial importance are those of the sea beaches of Travancore. Between Cape Comorin and Quilon there are five major deposits. The monazite is accompanied by quartz, garnet, zircon, magnetite, ilmenite and other minerals. It is extracted by washing followed by magnetic separation. Monazite owes its value to the small amount of thoria which it contains. This varies from 5 to 10 per cent., and constitutes the raw material for the preparation of thorium nitrate, used in the manufacture of incandescent gas mantles. Until 1911, when the monazite industry was started in Travancore, the world's supplies were practically all derived from Brazil. India obtained the lead in 1914, and has probably maintained it up to date. Output attained a maximum of 2,118 tons, valued at Rs. 8,82,285 (£58,819) in 1918. Since then, there has been a decline to 1,260 tons in 1921. The Indian monazite deposits are undoubtedly the largest known in the world, while as regards quality, the Travancore mineral easily comes first. The recent decline in

production is due to overstocking of the market, and it is doubtful if there can be any great expansion until some outlet is found for the present by-products.

G. H. Tipper: "The Monazite Sands of Travancore". *Rec. Geol. Surv. Ind.*, Vol. XLIV, pp. 186-196, (1914).

J. Coggin Brown: "Notes on Monazite". *Bull. Ind. Inds. Lab.*, No. 3, (1921).

NICKEL

India imports large quantities of nickel for coinage purposes and, in the form of "German-silver" for ornamental and domestic uses, but no nickel-bearing ores of any economic importance have as yet been discovered in the country. The presence of the metal has been detected in the complex sulphide ores of the Tovala taluk in South Travancore, which consist of mixtures of pyrrhotite, pyrite, chalcopyrite and other minerals; it has also been found in small quantities in sulphide ores from the Kolar gold field and elsewhere. It occurs, again in small amounts, in the lead-zinc sulphide ores of Bawdwin, and from time to time small parcels of nickeliferous speiss which have been accumulated in the course of smelting operations, appear in the returns from that source.

OIL SHALES

Oil shales were discovered a few years ago in the eastern portion of the Amherst district, Burma, near the Siamese frontier, where they occur in at least three basins of late Tertiary age. Recently a considerable amount of prospecting work has been done on the Tichara basin which lies in the valley of the Mepale river, some 60 miles east-north-east of Moulmein. The oil shales are said to occur in a series of seams, of which at least eight have been proved, varying from 4 to 16 feet in thickness, and large quantities are believed to be available.

Oil shales have also been found amongst the Tertiary deposits occupying the valley of the Theinkun stream, a branch of the Little Tenasserim River, Mergui district, Burma.

J. W. Gregory: "The Mepale Oil Shales, South Burma" *Min. Journ.*, Vol. CXL, No. 4566, p. 145 (1923).

M. Vinayak Rao: "Note on the Oil Shales of Mergui" *Rec. Geol. Surv. Ind.*, Vol. LIV, pp. 342-343, (1923).

PERIDOT

The peridot is a form of chrysolite or olivine, a mineral common enough in the ultra-basic rocks of India, though very rarely found fresh enough, or sufficiently clear, to be cut as a gem. According to Max Bauer, "the source of the chrysolite which is used in the trade for cutting as gems is somewhat obscure" and "both 'Pegu' and the 'country of the Burmese' are mentioned as localities for chrysolite, but the occurrence of the stone in gem-quality here or in India, is by no means well authenticated". The doubt regarding this matter may now be dispelled, for peridots of a very pleasing, olive-green colour are cut in Mogok from water-worn pebbles found in the ruby-bearing gravels there.

Max Bauer: "Precious Stones", (L. J. Spencer's translation), p. 407, (1904).

PETROLEUM

There are two zones of oil-bearing rocks in Burma which are separated by the mountain ridges known as the Arakan Yoma. The first includes all the occurrences of petroleum on the Arakan coast, is of no great importance as far as known at the present time, and is really the southern continuation of the oil-bearing belt of Assam. The second extends through the valleys of the Irrawaddy and Chindwin rivers and includes the fields of Thayetmyo, Minbu, Yenangyaung, Singu, Yenangyat and the Upper Chindwin. The oil is found in a group of Tertiary rocks known as the Pegu system, which consists of alternating bands of clays, shales, sandstones and impure limestones. After their consolidation these rocks were folded into more or less pronounced undulations, and the dome-shaped, or anticlinal, structures are those most favourable to the accumulation of oil "pools" in the sandy horizons, when these are sealed off by impervious layers of shale both above and below. The rocks were deposited in a shallow gulf of the sea into which a large river, the ancestor of the present Irrawaddy, poured the sediments that eventually filled it up. Rapid alternations of marine and estuarine deposits characterise the Pegu beds. The presence of petroleum underground is sometimes indicated by oil springs or seepages at the surface, though it by no means follows that an oil seepage proves the presence of a large oil

pool. Indeed, the distribution of petroleum, even where conditions appear to be very favourable, is capricious. Many of the sands when tested have been found to contain water, or, more rarely, gas. Water sands may also occur at intermediate horizons between profitable oil sands and during exploitation necessitate measures to prevent flooding.

THE BURMESE OILFIELDS

Yenangyaung

Yenangyaung, the most productive of the oil fields of Burma, lies some 2 miles to the east of the Irrawaddy at Yenangyaung, in the Magwe district. The oil-bearing strata form a symetrical, elongated dome, about 6 miles long and 1 mile broad, but the producing area does not cover more than $1\frac{1}{2}$ sq. miles.

Under the Burmese kings, the right to extract earth oil at Yenangyaung was vested in 24 families known as *Twinzayos*. The shallow oil sands, down to a depth of 200 or 300 feet, were reached by means of narrow, timbered shafts, from which the oil was baled in jars or lacquered baskets. The output from these shafts was about $2\frac{1}{2}$ million gallons per annum in 1888. Between that year and 1908, the use of a modified diving dress, which enabled the Burmese diggers to carry on their operations in an irrespirable atmosphere, resulted in their wells being carried to greater depths with a consequent rise in production. Thus in 1900, they yielded $8\frac{1}{2}$ million gallons. Since 1908, however, there has been a rapid decline as the *Twinzayos* have sold out their hereditary holdings to European companies. The modern exploitation of the field dates from 1887, when the Burmah Oil Co. Ltd. commenced drilling. Several other concerns now work in the 'reserves' of Twingon and Beme; the central section of the field, known as Khodaung, being leased to the Burmah Oil Co. Some years ago the keen competition of the various companies working in the reserves led to dangers from fire and flooding, but these matters are now controlled by a Warden and by an Advisory Board, composed of representatives of the companies themselves. From time to time the appearance of new water sands has led to rumours that the field was approaching exhaustion, but these have proved incorrect, as deeper oil sands continue to be tapped by the wells, some of which are now over 3,000 feet deep, and Yenangyaung still keeps up a fairly steady output in the neighbourhood of 200 millions of gallons per annum. The total depth to which petroliferous horizons will extend is quite unknown.

Singu

The Singu oilfield, in the Myingyan district, lies further north but on the same bank of the Irrawaddy as Yenangyaung; it is really the southern prolongation of the anticlinal fold that has given rise to the Yenangyat field. Its promising potentialities were first pointed out by the late G. E. Grimes of the Geological Survey of India in 1898. There are rich oil sands between the levels of 1,400 and 1,450, and 1,800 and 1,900 feet below the surface. For some years it was treated as a reserve by the Burmah Oil Co., but is now being steadily and scientifically developed by that concern. Its output today reaches well over 100 millions of gallons per annum.

Yenangyat

The Yenangyat field has a length of 39 and a maximum width of $3\frac{1}{2}$ miles, running for the greater part of its length as a steep scarp along the eastern bank of the Irrawaddy, in the Pakokku district. The Pegu rocks of which it is made, form a pronounced, asymetric, anticlinal fold, the eastern limb of which is highly inclined, vertical or even inverted. As a consequence the productive oil pools do not lie vertically below one another, as is the case at Yenangyaung, but are found at progressively greater distances to the west of the visible crest as the depth increases. Although the oil wells here have often commenced with considerable initial yields when the sands are first tapped, they fall off rapidly and the production from Yenangyat has never been very large. Beginning with 118,400 gallons in 1893 the drilled wells gave a maximum yield of over 22,600,000 gallons in 1903; but of late years a marked decline has set in and the field now only gives about $2\frac{1}{2}$ millions of gallons per annum.

Both the Yenangyat and Singu fields are connected by a pipe-line to Yenangyaung, and from there the crude oils are conveyed in a pipe-line 297 miles long, to the refineries near Rangoon.

Chindwin

The Upper Chindwin oilfield has been systematically prospected for some years by the Indo-Burma Petroleum Co. Ltd., and although several very large gas wells were struck, it did not enter the list of productive oilfields until 1918, when it yielded nearly half a million gallons. This has slowly increased to over 1,180,000 gallons in 1921.

Minbu

An acute anticlinal fold in Pegu rocks commences some 2 miles to the north of the town of Minbu, the headquarters of the Minbu district, and extends for several miles to the south-south-east. For a distance of 14 miles south of the town it is buried under a blanket of alluvium, but beyond this it becomes a broad arch, and further south still, a subsidiary fold appears. Near Minbu itself there are mud volcanoes and gas pools, which years ago led to extravagant ideas regarding the possibilities of the field. Many wells have been drilled in the more favourable localities but the results have been somewhat disappointing. Production commenced in 1910 with an output of 18,320 gallons. A maximum of $4\frac{1}{2}$ millions was reached in 1918 but this has fallen to 3,700,000 gallons in 1921. Owing to the narrow, asymmetrical character of the main fold, the area available for the storage of oil is strictly limited. Denudation has also removed the "cover" in places and permitted the oil to drain away, besides allowing water access to the sands, where, owing to the heavy nature of the oil itself, the two liquids mix readily. Further, many of the sands have proved to be barren.

Padaukbin

The small oilfield of Padaukbin lies on an anticline which forms a flat-topped, asymetric fold some 3 miles to the north-west of the town of Thayetmyo. Small quantities of oil were obtained from hand-dug wells in the time of the Burmese kings. Early efforts at deep drilling here only yielded small quantities of oil, but in 1920 further tests made by another company led to the production of 91,329 gallons, valued at Rs. 25,686 (£1,712) in 1920, and 66,372 gallons, valued at Rs. 33,186 (£2,212), in 1921.*

In addition to the main fields described above, petroleum is known to occur at many other places in the Burmese Oil

* The production of the Thayetmyo district in 1922 was 2,319,835 gallons.

Belt proper, while more or less favourable structures, without any surface indications of oil or gas, have been discovered during the systematic progress of the geological survey of the country. Descriptions of these cannot be given here, but may be found in Dr. E. H. Pascoe's standard treatise.

THE ARAKAN OILFIELDS

In addition to the oilfields of Upper Burma, the islands off the Arakan Coast, noted for their mud volcanoes, have also been known for many years to contain petroleum deposits of uncertain value. The districts which still appear in the returns are those of Akyab and Kyaukpyu. The Akyab oil comes from the Baranga Islands, of which there are three. Gas vents and oil seepages occur on them all, but the 9,700 odd gallons of oil, which is all the district now produces, come from hand-dug wells about 300 feet deep, situated near the southern extremity of the eastern island, where sandstones and shales, probably of Nummulitic age, are sharply folded. Years ago the output was much higher, thus in the quinquennial period 1904-1908 it averaged over 40,100 gallons per annum.

The Kyaukpyu oil is derived from the two small fields of Yenandaung and Ledaung on Ramri Island. The earliest accounts of the occurrence of petroleum in this, and the neighbouring island of Cheduba, date back to 1835. In 1880, several wells were drilled by the Canadian system on the Yenandaung field and although good yields were obtained at first, they gradually diminished and the industry is now in local hands. The bulk of the oil comes from a depth of 250 to 300 feet. The production of these two fields has never been large and has gradually diminished in recent years. Between 1904 and 1908 it averaged about 60,000 gallons per annum and in the succeeding quinquennial period 36,000 gallons. To-day it is approximately 30,000 gallons per annum. Dr. Pascoe's considered opinion is that folding and denudation have been too severe in these regions to warrant the expectation of oil in much quantity.

ASSAM

The rocks of the oil belt of Assam are believed to be of much the same geological age as those of Burma. They

extend from the Dehing basin in the extreme north-east of the province, along the outer flanks of the hill ranges forming the eastern border of the Brahmaputra and Surma valleys, to the islands off the Arakan Coast of Burma, a total distance of some 800 miles. Oil springs, seepages and gas "shows" are known to occur in the Cachar, Lakhimpur, Nowgong and Sibsagar districts, in the Khasi, Jáinti and Singpho Hills. These have all been described in a special memoir by Dr. E. H. Pascoe. The two producing fields of Digboi and Badarpur are situated in the Lakhimpur and Cachar districts respectively.

Digboi

The frequent occurrence of petroleum in connection with the coal seams of Upper Assam was known as long ago as 1838, but it was not until 1899, when the Assam Oil Co. Ltd. was formed, that the industry may be said to have started. The Digboi field covers an area of about 130 acres, the productive wells being situated on the southern flank of an asymetrical anticline. An oil sand crops out at the surface, but the principal supply is obtained from a sand between 1,400 and 1,700 feet underground. Gas invariably accompanies the oil and in most of the wells its pressure is sufficient to cause the oil to flow intermittently. Some trouble is caused by clogging of the wells with solid, paraffin hydrocarbons, with which the oil is saturated. The wax however is of fine quality and is a valuable constituent. The crude oil is distilled in a refinery on the field, and the principal products are kerosene, batching and lubricating oils, petrol, wax and wax candles and sundry oils, including fuel oil. The output of crude oil has steadily increased from 28,000 gallons in 1892, to over 5 millions of gallons in recent years. In 1921 the Assam Oil Co., Ltd. was absorbed by the Burmah Oil Co. Ltd.

Successful wells have also been drilled at Bappa Pung, situated about one mile to the east-north-east of the Digboi field.

Badarpur

The petroleum seepages which occur near Badarpur in the Cachar district were the first indication of the Badarpur oil field, a detailed, geological description of which has not yet been published. The first bore was put down by the Badarpur

Tea Company and the Badarpur Oil Boring Syndicate was registered in 1912. In 1915, it was announced that an agreement had been entered into with the Burmah Oil Co. Ltd. By 1917 the output of the field was nearly 3 millions of gallons, rising to over 8 millions of gallons, valued at Rs. 6,11,349 (£40,756), in 1920. In 1921 there was a decrease to about 4½ millions of gallons, valued at Rs. 3,34,611 (£22,308).

PUNJAB

Corresponding with the Arakan, or Shan, system of folded rocks on the east of Penisular India in Assam and Burma, and its extension to the south into the highly productive oil fields of Sumatra, Java and Borneo, there is a similar system on the west, in the Punjab and Baluchistan, with a continuation beyond British India into the rich oilfields of Persia and the possible ones of Mesopotamia. Oil springs and seepages occur in the Attock, Mianwali, Rawalpindi and Shahpur districts of the Punjab; in the Kohat district and Shirani Hills of the North-West Frontier Province.

" In many parts of the Punjab, however," writes Dr. Pascoe, "and in the Baluchistan area the rock-folds have been too deeply truncated by agents of denudation or have been dislocated by earth-movements, and much of the original stores of oil have disappeared, oil springs are common enough, but most of them seem to be mere "shows", not connected with reservoirs that can be tapped by artificial means".

Khaur

The Khaur oilfield lies upon the Potwar plateau, 43 miles south-west by west of Rawalpindi. Structurally it is a long, very slightly asymetric, open, anticlinal fold, about 7½ miles long and 1⅓ miles wide, at its broadest point. An oil seepage on it was first discovered by Dr. Pinfold, Geologist to the Indo-Burma-Petroleum Company. Drilling was commenced by the Attock Oil Company in 1915, and by 1917 five wells had been drilled, two to a depth of about 1,600 feet. Productive oil sands occur at depths of of 400, 450 to 500 and deeper sands down to 1,600 feet. The value of the sands shows a fairly constant increase with increasing depth. For some years the amount of oil taken from the field was little more than that necessary to test the wells. In Feb. 1922, however, a refinery was completed at Rawalpindi with a daily capacity of 65,000 gallons of crude oil to deal with the output.*

TRADE IN PETROLEUM PRODUCTS

India exports large quantities of petrol, benzine, paraffin wax and candles, which are amongst the products made from her crude petroleum. Thus, during the three years ending 1922, an annual average of over 20 millions of gallons of petrol and benzine valued at Rs. 2,06,94,000 (£1,379,600) was exported, for paraffin wax the corresponding figures were 27,262 tons, valued at Rs. 1,22,21,000 (£814,700), and for candles of all sorts, 2,772 tons valued at Rs. 18,56,130 (£123,742). Over 96 per cent. of the paraffin wax exports, and probably much the same proportion of candles, were from Burma.

India imports large quantities of petroleum products as may be seen from the following table.

Average annual importation of petroleum products for the three years 1920 to 1922

Kind	Quantity	Value	Value
	Gallons	Rs.	£
Kerosene	53,437,915	3,88,15,022	2,587,668
Fuel Oil	51,499,902	1,25,58,644	837,243
Lubricating & Batching Oil	17,817,355	2,27,30,084	1,515,339

Of the kerosene imports shown above, some 68 per cent. were from the United States of America, with smaller quantities from Borneo, Persia and other countries, though the imports from the latter country ceased in 1922. Of the fuel oil, approximately 73 per cent. of the total came from Persia and the rest from Borneo and elsewhere.

* The output from the Attock district in 1922 was 7,362,315 gallons, valued at Rs. 18,40,579 (£122,705).

QUANTITY AND VALUE OF THE PETROLEUM PRODUCED IN INDIA, 1919—1921

	1919			1920			1921		
	Quantity	Value		Quantity	Value		Quantity	Value	
	Gallons	Rs.	£	Gallons	Rs.	£	Gallons	Rs.	£
Assam ...	11,788,679	7,50,353	75,035	13,358,172	8,68,979	86,898	9,530,934	5,85,444	39,030
Burma ...	293,846,129	8,26,44,225	8,264,422	279,707,170	7,86,67,641	7,866,764	296,092,057	8,34,59,627	5,563,940
Punjab...	114,330	14,361	1,436	51,492	9,708	970	60,236	15,087	1,005
	305,749,138	8,34,08,939	8,340,894	293,116,834	7,95,46,328	7,954,633	305,683,227	8,40,59,627	5,603,975

E. H. Pascoe: "The Oil Fields of Burma." *Mem. Geol. Surv. Ind.*, Vol. XL, Pt. I (1912).

" "The Petroleum Occurrences of Assam and Bengal." *Mem. Geol. Surv. Ind.*, Vol. XL, Pt. II (1914).

" "Petroleum in the Punjab and North-West Frontier Province." *Mem. Geol. Surv. Ind.*, Vol. XL, Pt. III (1922).

PHOSPHATES

The most important occurrence of rock phosphate as yet discovered in India, is the belt of apatite-magnetite rock which has been traced from Patholgora in the Singhbhum district of Bihar and Orissa, to the south-east through Badia and the valley of the Sonk river to Bagjanta, a distance of about 7 miles, and from this vicinity with sundry breaks for a further 7 miles to Kedjurdari. According to Mr. Murray, the largest deposit of apatite is at Sungi, where the ore occurs as lenses in a biotite-schist band some 30 to 50 feet wide. The largest lens has a length of 120 feet with an average width of 12 feet, but the mean width of the entire ore shoot does not appear to be more than 3 feet. The proportions of apatite (the fluo-phosphate of calcium), to magnetite vary greatly, but the average appears to be about 20 to 25 per cent. When cleared of magnetite the apatite is said to be of high grade, containing over 80 per cent. of tri-calcic phosphate. In 1918, a company was floated to work these deposits, a certain amount of development was carried out and a mill was erected but the company later went into liquidation.

The only other occurrence which need be mentioned is the deposit of septarian nodules occuring in the Cretaceous beds of Perambalur taluk, Trichinopoly district, Madras. Dr. H. Warth estimated in 1893 that to a depth of 200 feet the beds contained nodules to the amount of 8 millions of tons, but the phosphates are irregularly distributed, varying from 27 to 70 lbs. per 100 cubic feet. They contain from 56 to 59 per cent. of phosphate of lime with about 16 per cent. of carbonate of lime. Attempts to utilize these and similar natural phosphates have not been encouraging.

An immense majority of the population of India is occupied directly or indirectly in agriculture and the chief obstacle to the improvement of Indian agriculture is the need of manure. "Water and manure together," writes Dr. Voelcker, ("Improvement of Indian Agriculture" Chap. VII) "represent in brief the ryot's main wants." According to Mr. J. W. Mollison, late Inspector-General of Agriculture, "A great deal of land, particularly in the poorer tracts of Peninsular India, is slowly undergoing exhaustion for lack of manuring, ("Imperial Gazetteer" Vol. III, page 21, 1907), yet the deposits of the mineral phosphates which might form the basis of valuable fertilizers remain unworked, and immense quantities of phosphates and other fertilizers in different forms are exported every year." During the three years ending 1921-1922, the average annual value of artificial and mineral manures imported into India was a little over 28 lakhs of rupees, while the exported material including bones, fish guano and sulphate of ammonia, had an average annual value of almost 131 lakhs of rupees.

PLATINUM

Small quantities of platinum and of the other allied metals known under the group name of iridosmine, are sometimes found accompanying gold in alluvial deposits. Thus platinum accurs with gold in the sands of the Noa Dihing river, Lakhimpur district, Assam, and under similar conditions in the Chindwin river and its tributaries in Burma. These occurrences have led to the hypothesis that the platinum may originate in the great serpentine intrusions of the Patkoi range and Arakan Yomas, especially as platinum is sometimes associated with similar rocks in other parts of the world. Small amounts of the metal used to be obtained regularly by the Burma Gold Dredging Company, from the gold-bearing, alluvial gravels of the Irrawaddy and its branches above Myitkyina. For example, between the years 1911 and 1915, a total of 206 ozs. was returned.

POTASSIUM SALTS

Salts of potassium consisting of mixtures of the minerals sylvite (potassium chloride), and langbeinite (a double sulphate of potassium and magnesium), with kieserite (a hydrated sulphate of magnesium), and common salt, were discovered in the Mayo Mines of the Salt Range in 1873. Potash salts are of great economic importance especially for agricultural purposes, and practically the whole of the world's supply comes from the mines of Northern Germany. The occurrences of the Salt Range were investigated by Dr. Christie in 1913. He found new deposits in the Mayo Mines at Khewra, and in the Nilawan ravine near Nurpur, several miles further west. One seam in the Mayo Mines with an average thickness of about 6 feet, was provisionally

estimated to contain 3,000 tons of potash. The seams, however, appeared to thin out along the rise of the strata. The percentage of potash in average bulk samples ranged from 7·7 to 14·4. At a later date the subject was studied again by Dr. Murray Stuart, who concluded that the salts occur in disconnected lenticles and irregular foliae and not in continuous beds. He considers that the prospects of obtaining potash salts in the Salt Range are not promising and that they are not likely to be won profitably except as by-products of salt mining.

W. A. K. Christie: "Notes on the salt deposits of the Cis-Indus Salt Range". *Rec. Geol. Surv. Ind.*, Vol. XLIV, pp. 241-264 (1914).

M. Stuart: "The Potash Salts of the Punjab Salt Range and Kohat". *Rec. Geol. Surv. Ind.*, Vol. L, pp. 28-56 (1919).

RARE MINERALS

Columbite and tantalite, the niobate and tantalate of iron and manganese, are sometimes met with in the mica-bearing pegmatites of Bihar and Orissa and of South India. As there appear to be no commercial uses for niobium (columbium) at present, while tantalum has at least one application in the filaments made from the metal for electric lamps, the value of mixtures of these two minerals, which may occur in any proportions, depends on the amount of tantalic oxide present. Unfortunately, tantalite is very much rarer in India than columbite. Some of the finer examples of the latter mineral come from the Singar estate, Gaya district, Bihar.

Amongst the rare earth minerals occurring in India, the following may be mentioned, in addition to monazite already described. Samarskite, a complex niobate and tantalate of uranium, the yttrium earths and iron, which occurs in a mica-bearing pegmatite at Sankara, near Gridalur, Nellore district, Madras, and is strongly radioactive. Gadolinite, a silicate of yttrium, beryllium and iron, has been found in a tourmaline pegmatite in the Palanpur State, Bombay. Allanite, a hydrous silicate of calcium, aluminum, iron and the rare earths, has been obtained from certain of the Nellore pegmatites and from others in Bihar and Orissa.

G. H. Tipper: "On Pitchblende, Monazite and other Minerals from Pichhli, Gaya district, Bihar and Orissa." *Rec. Geol. Surv. Ind.*, Vol. L, pp. 255-262 (1919).

RUBY

The ruby mines of Mogok in Upper Burma were worked at least as early as the fifteenth century. They are alluded to in the writings of Cæsar Fredericke, who visited Pegu in 1569, and by Ralph Fitch in 1586, though the earliest record of a visit to the mines was not given until 1833 by Pére Guisèppe d'Amato. The mines have undoubtedly yielded the greater part of the rubies used in the world's jewellery, including the finest specimen stones known, for although rubies do come on to the market from Siam, Ceylon and elsewhere, the clear, limpid, deep-crimson-red of the Burmese ruby is incomparable. The shade which is most admired is a transparent carmine red with a suggestion of a bluish tinge known as "pigeon's blood". (The term is probably derived from the Burmese, and the tint is said to be the same as that of the blood exuding from the beak of a wounded pigeon—an odious comparison, but one which cannot be replaced). The Ceylonese rubies are usually of a magenta, and the Siamese stones of a claret colour.

In the Ruby Mines district there is a series of narrow, parallel, lenticular bands of crystalline limestone stretching from Mogok to Thabeikkyin, a distance of 40 miles, but the productive workings are confined to the eastern end between Shwenyaungbin and Mogok. The native workings, which are still extensively carried on, are either small quarries in the detritus filling fissures and hollows in the limestone, or cuttings driven into the rainwash of the limestone slopes, or pits sunk into the alluvial deposits of the valleys, to reach the gem-bearing gravel or "byon" which lies at a considerable depth, and into which the gems have found their way from the decomposing limestone.

In 1889, a lease of the ruby-tracts was granted to the Burma Ruby Mines Company, which has since that time systematically exploited the alluvial deposits. The gravel is washed out of large excavations by hydraulic methods, and, after being classified into various sizes, the lighter minerals are removed by pulsators and the gems picked from the concentrate by hand. Writing in 1917, Mr. A. H. Morgan, Chief Engineer of the Ruby Mines Company for many years, stated: "During the last thirty years, the value of the

rubies found by the Burma Ruby Mines, Limited, amounted to a million and a half pounds; the natives probably found as much, say, a total of three millions, or one million pounds worth in ten years." It is a commonplace remark that the ruby is a more valuable stone than the diamond, but this only applies to perfect rubies of large size. The best-quality ruby begins to rival the best-quality diamond when it is about 2 carats in weight, but beyond that, the ruby greatly exceeds the diamond in value. Diamonds of larger sizes are comparatively common, thus 10 carat stones can be had in abundance, but a perfect ruby of 10 carats is a most exceptional stone. A ruby, in the rough, found by Mr. Morgan weighed 9 carats, and was sold for Rs. 27,000; after cutting to 6 carats, it was sold again for Rs. 30,000. A stone of 21 carats, cut to 13 carats, sold for Rs. 1,12,500. Another stone, weighing 36 carats, sold by Mindon Min, the father of the last Burmese King, brought Rs. 4½ lakhs or £130,000 an ounce, while a perfect diamond of the same weight, we are told, might perhaps sell for Rs. 75,000.*

From the commercial point of view the mining of coloured gems is always a speculative business, dependent as it is for its profits on the erratic movements of a particularly sensitive market, which reflects in its turn all the vagaries of fashion. For the three years ending 1920, the average annual production of rubies at Mogok was 92,992 carats, valued at Rs. 6,48,782 (£43,252). In 1921, 112,197 carats were returned, valued at Rs. 6,91,209 (£46,080).

Rubies are also known to occur near Sagyin in the Mandalay district and at Naniazeik in the Myitkyina district of Upper Burma. No output has been reported for some years from either area.

C. Barrington Brown and J. W. Judd: "The Rubies of Burma and Associated Minerals". *Phil. Trans.*, Vol. CLXXXVII—A, pp. 151-228 (1895).

A. H. Morgan: "Precious Stones". Lectures delivered at Tavoy under the Auspices of the Mining Advisory Board. Vol. I, pp. 71-80, (1918).

* The year 1922 was marked by the discovery at Mogok of an exceptionally valuable ruby of nearly 23 carats. The stone is of such rare size and quality that it is anticipated to be worth several thousands of pounds sterling.

SALT

The following table shows the production of salt in India during the last three years for which statistics are available, together with the quantities which have been imported into the country from abroad :—

Year			Production Tons	Imports Tons	Total Tons
1919	...	...	1,891,138	481,749	2,372,887
1920	...	...	1,630,123	614,674	2,244,797
1921	...	...	1,533,679	479,306	2,012,985

About 60 per cent. of the Indian total is derived from the evaporation of sea water carried on during the hot weather on the coasts of Bombay, Madras and Burma. In the case of the last named province, suitable pieces of ground are first prepared just above the level of spring tides. Then brine is raised at high water, by means of the Chinese paddle wheel, and it flows by gravity from one evaporating ground to the next, in each of which it is allowed to remain for a time. The water is gradually driven off by the heat of the sun, and the final, strong, salty liquor is boiled down to dryness in shallow, iron pans heated by wood fires. The solar evaporation is aided to a great extent by the strong, dry winds which normally prevail at the season.

Salt is also made from sub-soil and lake brines, especially in the desert region of Rajputana, from which about a quarter of a million tons are obtained every year. It has been proved that most of this salt is carried in as fine dust by the winds which blow across the Rann of Cutch during the hot weather. Sambhar, the largest of the salt lakes of Rajputana, occupies an area of 60 to 70 square miles during the monsoon, when the rivers flooded by the rains and flowing over regions more or less impregnated with salt, dissolve the mineral and carry it into the lake. Specially

prepared enclosures cut off bodies of the lake-water, and as the hot season advances solar evaporation takes place and the salt is recovered. By the next March or April the lake has shrunk greatly, and its dry bed is covered with a thin crust of salt, which is allowed to remain until the arrival of the next monsoon. Since it was taken over by Government in 1870, the Sambhar lake has yielded over 6 millions of tons of salt.

Sub-soil brine is utilised at Pachbhadra in Rajputana and at other places in India. It is also the source of the salt produced in some districts of Upper Burma.

About one-tenth of the Indian salt output comes from the rock salt mines of the Salt Range of Kohat and of Mandi State. In the Mayo mines at Khewra, in the Salt Range of the Punjab, the seams of salt and included partings of marl have an aggregate thickness of 550 feet, of which 5 seams of pure salt make up 275 feet. In this region salt quarrying was carried on for unknown period before the time of Akbar. The industry passed under the control of Government in 1849, but it was not until 1872 that proper mining methods were introduced, following a system designed by an officer of the Geological Survey of India. There are various other mines in the Salt Range which cannot be described here.

In Kohat, the salt resources are said to be practically inexhaustible. At Bahadur Khel the salt beds have a thickness of over 1,000 feet and have been traced for a distance of about 8 miles.

Sir T. H. Holland and W. A. K. Christie: "The Origin of the Salt Deposits of Rajputana." *Rec. Geol. Surv. Ind.*, Vol. XXXVIII, pp. 154-186, (1909).

M. Stuart: "Suggestions regarding the Origin and History of the Rock Salt Deposits of the Punjab and Kohat," *Rec. Geol. Surv. Ind.*, Vol. L, pp. 57-97 (1919).

SALTPETRE

Many years ago India possessed a virtual monopoly of the world's supply of nitrates, so important in the manufacture of explosives and chemical manures. Sir Thomas Holland has shown how the circumstances which are essential for the formation of saltpetre in a soil are practically ideal on the plains of Bihar. Here, there is a dense, agricultural population using wood and cow-dung as fuel, possessing large herds of cattle which supply abundant organic nitrogen, and living under most favourable climatic conditions. As a consequence, the moisture which is continually rising to the surface, leaves efflorescences in which saltpetre, the nitrate of potassium, is conspicuously present. The process of manufacture is simple. The efflorescent salts are scraped from the ground and the soluble contents extracted by water, which has been made to percolate through layers of wood ashes in crude filters. The liquor is evaporated and the mixture of salts separated by fractional crystallization. The saltpetre is sent to refineries for further purification before export. Large quantities of saltpetre are also made in the United Provinces and the Punjab, while smaller amounts are derived from Rajputana and Nepal.

The average annual export of Indian saltpetre during the years 1791 to 1805 was about 80,000 tons. For the years 1876 to 1880 it was about 21,000 tons. After that time a decline set in, the average for the five years 1909-1913 being 16,570 tons. The industry has always responded to war conditions, and it is interesting to note that it reached its zenith at the time of the American Civil War, when the value of the exports ranged between £600,000 and £900,000 per annum. It was only to be expected therefore, that a revival would take place from 1914 onwards, and this proved to be the case, for the annual exports for the period 1914-1918 averaged 21,737 tons valued at £517,790. In normal times the tea, rubber and coffee gardens of Ceylon and Java, the sugar plantations of Mauritius and the cotton fields of the United States of America consume much of India's saltpetre; in war times it is diverted to the explosives' factories. Production in 1920 was 15,018 tons, valued at £540,012. Calcutta is still, as it always has been, the chief market and port through which the mineral leaves India and 80 to 90 per cent. of the export trade is handled there.

T. H. Holland: "Sketch of the Mineral Resources of India". pp. 58-60 (1908).

J. W. Leather and J. N. Mukerji: "The Indian Saltpetre Industry". *Bull. Agric. Res. Inst.* Pusa., No. 24 (1911).

SAPPHIRE

The rubies of Upper Burma are invariably accompanied by sapphires, found in the same gem gravel and derived in the same manner from the crystalline limestones, but the proportion of the blue corundum is usually much smaller than that of the red variety present, though the stones themselves are often of larger sizes. The blue shade of the sapphire may vary a great deal, from quite a pale colour to a dark indigo blue. The best varieties are cornflower blue with a soft velvety sheen. The Burmese gems, as a group, tend towards the darker tints. Their value is much less than that of the ruby, and, as a general rule, a perfect ruby of medium size is rated at ten times the value of a similar sapphire. The sapphire market is a very variable one, and as Germany seems to be the chief buyer, the stones are most in demand when that country is prosperous. For the three years ending 1920, an average annual output of 38,417 carats of sapphires, valued at Rs.1,15,367 (£7,691), was produced. In 1921, the figures were 48,916 carats valued at Rs.57,232 (£3,815).

An accidental discovery of sapphires in large quantities, was reported from the southern slopes of the Zanskar range, below the Umasi pass, in Kashmir early in 1882. The gems occur both *in situ* in a pegmatite vein, and in the detrital deposits of the valley below its outcrop, from which they were obtained by washing. For some years the State derived a considerable revenue from the mines, which were abandoned under the impresssion that they were exhausted. In 1906, however, work was commenced again by the Kashmir Mineral Company, and at first several valuable stones were obtained, one of them being sold for Rs. 30,000. Very soon, however, the production fell off, and the mines have not been operated since 1908. The locality is 14,000 feet above sea-level, and is under snow and inaccessible for the greater part of the year.

T. H. D. La Touche: "The Sapphire Mines of Kashmir." *Rec. Geol. Surv. Ind.*, Vol. XXIII, pp. 59-69 (1890).

SILLIMANITE

Sillimanite, the silicate of aluminium, occurs in large radiating aggregates with quartz, mica, rutile and other minerals in the vicinity of Nongmaweit in the Khasi Hills, Assam. Corundum is also found in the same vicinity, and during the war large quantities of both minerals were extracted for abrasive purposes, the average annual output for the four years ending 1919 being 2,136 tons. Most of this material came from detached boulders lying on the surface of the soil, and the exact mode of occurrence is at present obscure. The mineral forms a valuable refractory, especially for glass furnaces, and there appears to be a future for it, provided it exists in large quantities and can be landed in industrial centres in Europe and America at cheap enough rates.

Water-worn crystals of sillimanite (fibrolite) occur in the hill-wash of the Burma Ruby Mines at Mogok. When facetted and polished they form clear, transparent, pale sapphire-blue gems somewhat resembling cordierite (iolite), the water-sapphire.

SILVER

It has been proved by analysis that many of the lead ores which occur in small quantities scattered over the Indian Empire, are argentiferous, but none of them have as yet proved to be of any economic importance, with the single exception of those of Bawdwin in the Northern Shan States, (See "Lead"). The average silver content of the lead ore from the "Chinaman" ore-body there is 25 ozs. of silver per ton of lead. By concentration in the milling, flotation and slime plants this is increased to about 40 ozs. before the mineral is sent to the smelter. After the crude metallic lead has been extracted in the blast furnace, it is refined and the silver finally separated. In 1921, 3,555,021 ozs. of silver valued at Rs. 88,20,855 (£ 588,057) were produced. Most of the Burmese silver finds its way into the Indian coinage. The metal is also obtained as a by-product in the extraction of gold from the Anantapur mines in Madras and the Kolar mines in Mysore. In 1921, the former yielded 619 ozs., and the latter 31,947 ozs. It is unlikely that the latter two localities will show any marked increase, but as the production of lead expands in Burma, the output of silver should become greater in much the same ratio.

SODIUM COMPOUNDS

In addition to sodium chloride various other salts of sodium occur in India, notably the sulphate and the carbonate. The saline efflorescence known as *reh*, which is commonly found on the surface of the soil in the drier parts of the Peninsula and which has such a deleterious effect upon the productive capacity of the land, contains the chloride, sulphate and carbonate of sodium. Many years ago there was a considerable production of both the latter salts, which was used in the manufacture of glass and soap and for curing hides and skins, but the indigenous industry has been largely displaced by the importation of cheap materials from abroad. The annual total imports of sodium salts during the five years ending 1918 averaged 805,776 cwts., valued at £494,635, while a large works near Calcutta now manufactures them locally from the crude sodium carbonate of Lake Magadi in East Africa.

Sulphate of soda is still obtained as a by-product in the manufacture of saltpetre. Both the sulphate and the carbonate occur in the brines of the Rajputana salt lakes. The water of a shallow lake near Lonar, Buldana district, Central Provinces, contains a large proportion of carbonate of soda which crystallises out as the lake dries up in the hot season, and which was extracted for use in the manufacture of glass and soap on a much larger scale than it is to-day. Dr. Cotter has recently described the soda industry of Eastern Sind. There, the mineral in the form of either fairly pure sodium carbonates, or of mixtures of the carbonates, chloride and sulphate is collected from the *dhands* or alkaline lakes, during the hot weather, at the periods of maximum evaporation. The minerals are either used locally or exported from Karachi. The alkaline lakes are found exclusively in that portion of Sind which is covered by wind-blown sand and are divided into two geographical groups.

(1) The Nara group lying in Khairpur State, with a southward extension into the Nawabshah district, and the Sanghar taluk of Thar and Parkar.

(2) The Jubo group, situated entirely in Khairpur.

The efflorescent sodium salts which collect on the low-lying gneissic country, and, particularly, on land which is marshy, in parts of Mysore, have been the subject of several recent investigations by officers of the Mysore Geological Survey whose reports should be consulted.

E. R. Watson and K. C. Mukerji: "The Extent and Nature of the *reh* Deposits of the United Provinces." *Journ. Ind. Inds. Lab.*, Vol. II, pp. 13-28 (1922).

G. de P. Cotter: "The Alkaline Lakes and Soda Industry of Sind." *Mem. Geol. Surv. Ind.*, Vol. XLVI, Pt. 2. (1923).

SPINEL

Quantities of spinels of very beautiful red, scarlet and rose colours, are obtained with the rubies of Upper Burma under identical conditions; indeed, the deep-red, Burmese spinel is frequently mistaken for the ruby by the uninitiated, but its market value is very much less. For the three years ending 1920, an average annual production of 28,024 carats of spinels, valued at Rs. 4,297 (£286), was recorded from Mogok. In 1921, the corresponding figures were 32,802 carats valued at Rs. 4,207 (£280)

STEATITE

Steatite, soapstone or potstone, is a common mineral in India, though impure varieties of talcose schist are often included in these terms. Pure steatite has many applications in the arts and is used extensively in the paper, textile, rubber and soap industries. The powdered mineral, commonly known as "French Chalk," forms the basis of many toilet preparations. In India, steatite is carved into images, bowls, plates and ornamental articles, and there is believed to be a trade of considerable extent in the material in almost every province which does not appear in the official returns. The data that are available show a gradual increase in production. For example, in 1914 about 1,000 tons were reported; in 1917 nearly 3,000 tons; in 1918 about 4,500 and in 1921, 5,700 tons, valued at Rs.88,202 (£5,880). The Jubbulpore district of the Central Provinces, considered over a number of years, returns the largest output. There, the deposits are on the north side of the Marble Rocks in the Nerbudda Valley, where the mineral forms pockets in

the dolomitic limestone of the gorge. Smaller amounts come from the Singhbhum district and the Mayurbhanj State of Bihar and Orissa, from the Salem and Nellore districts of Madras, from Mysore, from the Hamirpur and Jhansi districts of the United Provinces, and from the Minbu, Meiktila and Pakokku districts of Burma. In 1911-12, Mr. C. S. Middlemiss of the Geological Survey of India, discovered a large deposit of steatite of very fair quality near Dev Mori in Idar State, Bombay. He calculated that 2 million tons are available in the first 20 feet from the surface, as the bed of steatite is over 1 mile long with a width of over 200 feet.

Dr. A. M. Heron has drawn attention to some undescribed steatite deposits in Jaipur State, Rajputana. The largest of these is at Mora-Bhandari, where one of the beds measures 25 feet in thickness, while pockets of steatite extend over a distance of 5 miles.

Personal enquiries in the London market have convinced the writer that the failure of Indian steatite to obtain a footing there is largely due to two causes, the first, that greenish varieties have been offered instead of the pure white ones, and the second, that sufficient care has not been exercised in the powdering operations.

C. S. Middlemiss: "Note on Steatite Deposits, Idar State." *Rec. Geol. Surv. Ind.*, Vol. XLII, pp 52-53 (1912).

A. M. Heron: "The Biana-Lalsot Hills in Eastern Rajputana" *Rec. Geol. Surv. Ind.*, Vol. XLVIII, p 200, (1917).

STRONTIUM

Celestite, the sulphate of strontium, has been found scattered sparingly over the surface of the Khirthar limestones of Kohistan (Sind), especially east of the range to the eastward of Thana Bula Khan. The mineral occurs in crystalline lumps about the size of walnuts, but there is no information as to the quantity available. It is also said to have been found in red clays of Tertiary age near Surdag, in the Kohat district of the North-West Frontier Province.

Strontium salts are used chiefly in sugar refining and pyrotechny, but no statistics are available to show the quantities imported into India.

SULPHUR

The largest known occurrence of sulphur in India is that of Sanni, in the Kachhi district of Kelat State. The reserves of the mine are estimated at 36,000 tons of sulphur-rock averaging 28·8 per cent. of sulphur. Small quantities of the element are also obtainable on the volcanoes of Koh-i-Sultan in Baluchistan and Barren Island in the Bay of Bengal, but it is doubtful whether these and a few other reported occurrences in India are worth working.

India is strangely poor in deposits of sulphur or the natural sulphides which might be utilised in the manufacture of sulphuric acid. It has been stated that this acid is the most essential material in use in the chemical industry, and that the quantity consumed by any particular country is a measure of its industrial advancement.

Pyrite, the sulphide of iron, occurs in shales associated with the coal measures of Assam, it is abundantly disseminated through certain rocks in Dhalbhum (Bihar and Orissa). It has been found in Hyderabad, Mysore and the Shan States: indeed, it is a common mineral in small quantities practically everywhere, but no pyrite deposits of any economic importance have been found.

It is estimated that the Indian imports of sulphuric acid in 1913 averaged about 2,500 tons. For the three years ending 1921, the average was 247 tons, but India now manufactures about 20,000 tons of the acid per annum, which is practically all made from imported sulphur of Japanese, Sicilian and American origin. When it is remembered that the world's annual production of sulphuric acid exceeds 10,000,000 tons, the truth of a remark by a recent writer on this subject (C. S. Fox) is at once apparent. "If the demand for sulphuric acid is taken as the chemical barometer of industrial conditions, industrial activity in India is in its infancy."

Without cheap local supplies of sulphuric acid this country will never attain the position which her wealth of mineral products warrants. Fortunately, in the lead-silver-zinc sulphides of Bawdwin there is a reserve of sulphur, sufficient all demands for the present, and it is greatly to be

regretted that the proposal to utilise them has not materialised.

G. de P. Cotter: "Report on the Sanni Sulphur Mine". *Rec. Geol. Surv. Ind.*, Vol. L, pp. 130-138, (1919).

C. S. Fox: "Notes on Sulphuric Acid, Sulphur and Iron Pyrites." *Bull. Ind. Inds. Lab.*, No. 28, (1923).

TIN

Cassiterite, or tin-stone, the oxide of tin, is practically the only ore of this metal. It occurs sometimes in the mica-bearing pegmatites which traverse the crystalline rocks of Bihar and Orissa. Thus it has been found at Pihra and Domchanch in the Hazaribagh district and elsewhere, but these occurrences are merely of scientific interest. The cassiterite deposits of Burma have been worked from a remote antiquity. The mineral often accompanies wolfram in Burma and the conditions under which the former is found apply equally to the tin ore, except that it is also present in the alluvial deposits of the rivers while wolfram is not. The mountain ranges of Lower Burma are merely the northern continuation of the same rocks that have furnished the rich and well-known tin-stone deposits of the Malay Peninsula and Western Siam. There are important mines in the Bawlake State of Karenni, and in the Tavoy and Mergui districts. Alluvial workings are widely distributed over Mergui, but mining methods are very primitive and output low. The best known centres are Karathuri on the coast and Thabawleik on the Little Tenasserim River. In Tavoy district, alluvial tin mining is carried on at Hermyingyi, Taungpila and Kanbauk. At Taungthonlon, on the Hindu chaung, bucket dredgers are at work on the river gravels. There are other concessions in the Amherst and Thaton districts.

The official returns do not reveal the true position of the cassiterite production of Burma. The mixed concentrates that are produced at the mines are tabulated as wolfram, although they often contain varying percentages of tin ore which is not entirely separated in Burma, although a good deal of it is removed by the magnetic separator plant installed in Tavoy. The writer has calculated that in 1918 Burma turned out the equivalent of 1,261 tons of metallic tin. The imports of tin into India during that year were

1,229 tons. In other words, if the ore had been smelted in the country, the Indian Empire was self-supporting as regards this metal for that year. A certain amount of tin ore is smelted in Mergui by Chinese methods but the greater part is sent to the Federated Malay States for treatment. The production for 1920 and 1921 was as follows:—

	Metallic Tin			Tin Ore		
	Tons	Value		Tons	Value	
		Rs.	£		Rs.	£
1920 ...	165	5,95,640	59,564	3341	26,60,624	266,062
1921 ...	171	4,62,104	30,807	1702	19,79,441	181,963

The decrease in 1921 was due to the almost complete cessation of production in the Southern Shan States, for both Tavoy and Mergui registered increases.

A great deal still remains to be done in the better equipment and further development of the tin-stone deposits, both vein and alluvial, which are known in the Tenasserim division of Lower Burma, while further search in likely localities will probably lead to the discovery of new ones.

J. Coggin Brown and A. M. Heron: "Geology and Ore Deposits of the Tavoy District." *Mem. Geol. Surv. Ind.*, Vol. XLIV, (1923).

TITANIUM

Ilmenite, the titaniferous iron ore, has been noticed as a common, accessory mineral in the crystalline rocks of many parts of India and Burma. The largest deposits are those of the beach sands of Travancore, where it is associated with monazite and zircon. Ilmenite is now used on a large scale for the manufacture of "titanium white," a permanent pigment which is said to possess all the good qualities and none of the objectionable feature of white lead and the white zinc pigments. In the Travancore deposits, India possesses very large reserves which should be capable of profitable exploitation.

TOURMALINE

Red tourmaline or rubellite is obtained in small quantities in the Ruby Mines district of Upper Burma, and it used to be mined on a fairly large scale near Maingnin, Mongmit State, Burma. The matrix of the gems was a vein of white, decomposed granite in which square shafts, 60 to 100 feet deep, were sunk. No returns of output have been forthcoming since 1909. The mineral is greatly prized by the Chinese, and perhaps one of the reasons for the abandonment of the mines, both in Möngmit and Möng Lõng is to be found in the fact that a better variety, of a deeper tint, is now obtainable from Brazil. Green tourmaline also occurs at Mogok, but it has practically no value there. A crystalline limestone containing green tourmaline used to be worked in desultory fashion at Namon in the Southern Shan States. The mineral also occurred at the Zanskar (Kashmir) sapphire mines, while both the green and blue varieties are sometimes found in the mica-bearing pegmatites of the Hazaribagh district, Bihar.

F. Noetling: "Note on the Tourmaline Mines in the Mainglon State". *Rec. Geol. Surv. Ind.*, Vol. XXIV, pp. 126-128 (1891).

E. C. S. George: "Memorandum of Tourmaline Mines of Maingnin". *Rec. Geol. Surv. Ind.*, Vol. XXXVI, pp. 233-238, (1908).

TOPAZ

Topaz is a rare mineral in India. It occurs in association with fluorite at Hermyingale, Tavoy district, Lower Burma; near a cassiterite, wolfram, quartz vein, in the cassiterite concentrates obtained by dredging at Taungthonlon in the same district, and in a pegmatite vein at Sakangyi in the Katha district, Upper Burma. These occurrences are only of scientific interest. Precious topaz, transparent, perfectly colourless and pellucid, is found in the gem gravels of the Ruby Mines, Burma, in the form of slightly water-worn crystals often of considerable size.

URANIUM

Pitchblende, the chief ore of uranium and of radium, has been found in pegmatite veins at Abraki Pahar and at Pichhli in the Gaya district, Bihar and Orissa. In the former locality it is associated with triplite, a phosphate of iron and manganese, and in the latter with monazite, apatite and columbite. The radium content of the pitchblende is stated to be high. A company was formed for the exploitation of the Abraki Pahar occurrence, but prospecting operations did not show any indications of a large deposit and liquidation took place in 1914.

WOLFRAM

Wolfram, a tungstate of iron and manganese, is the chief ore of tungsten. This metal is an essential ingredient of the high-speed steels, which in the last two decades have revolutionised the machine shop practice of the world. Under favourable conditions, one man and one lathe can do as much work with high-speed steel as five men and five lathes could do formerly with simple carbon steel tools. An American writer has rightly stated, that to deprive a nation of tungsten is to cripple its military power and to ruin its industrial life in times of peace. Tungsten has numerous other uses, especially for the preparation of the metallic filaments of incandescent electric lamps, millions of which are now made annually.

Wolfram occurs in the Singhbhum district of Bihar, at Agargaon in the Central Provinces, and at Degana in the Marwar district of Rajputana, but these deposits are insignificant compared with some of the Burmese ones. In that province wolfram has been found at intervals over a distance of more than 700 miles, from the Kyaukse district in the north through the Yamethin district, the Southern Shan States and Karenni, to the Thaton, Amherst, Tavoy and Mergui districts in the south. It is always intimately associated with the granite which forms the core of the northern extension of the Indo-Malayan mountain system in Burma, and continues to the south through Lower Siam and the Malay States, to Banca and Billiton in the Dutch East Indies. The Tavoy district is by far the most important, and in it the wolfram occurs associated with tin-stone, iron pyrites and mica, and sometimes with copper pyrites, zinc blende and galena, in quartz veins which penetrate the granite and the surrounding rocks. Wolfram is also found in profitable quantities in the soil and detritus

of the hill sides, which it reaches when the parent veins disintegrate under the action of the weather.

Wolfram was known to occur in Tavoy before 1850, but it was entirely forgotten until rediscovered by an officer of the Geological Survey about 1909. Mining commenced in 1910, and in 1911 an output of 1,300 tons made Burma the leading wolfram-producing country in the world, a position she maintained till 1916, when the boom created by the war caused the production of the United States and of Bolivia to surpass hers. By 1917 large quantities were also shipped from China. The wolfram deposits of Burma were of supreme importance to the Empire during the Great War, and between 1914 and the Armistice no less than 17,642 tons, of a total value of £2,323,000, were exported. Of this quantity over 14,000 tons came from the Tavoy field. Since the end of the war there has been a slump in the industry, and in 1921 India produced only 898 tons, valued at Rs. 4,39,388 (£29,292).

The Tavoy deposits are worked by many different methods from the wasteful and ancestral Chinese practices on the one hand, to the use of modern concentrating mills and hydraulic plant on the other, and there is no doubt that they are still capable of supplying large quantities of wolfram to the markets of the world, should the demand for it arise again.

J. Coggin Brown and A. M. Heron: "The Distribution of the Ores of Tungsten and Tin in Burma". *Rec. Geol. Surv. Ind.*, Vol. L, pp. 101-121, (1919).

J. Coggin Brown and A. M. Heron: "The Geology and Ore Deposits of the Tavoy district". *Mem. Geol. Surv. Ind.*, Vol. XLIV (1923).

ZINC

Zinc blende, the sulphide of zinc, occurs at Jawar in the Udaipur State of Rajputana, where it was mined extensively in the 17th century. The mines were closed about 1812. The mineral is also found at other places, but the most important deposit is that of Bawdwin in the Northern Shan States, where it is associated with lead, silver and copper minerals.

During the years 1913 and 1914, quantities of zinc concentrates (averaging some 5,000 tons per annum) were shipped from Burma to Belgium and Germany, and in 1916 Japan was a buyer. At the present time, the freight costs to Europe, together with the high smelting charges, do not make it profitable to export the mineral at the prevailing price of zinc. India consumes large quantities of zinc, not only in the form of the pure metal, but in brass and other alloys, and in galvanized sheets. The average annual imports of galvanized goods, for the three years ending 1914, were valued at over £2,660,000 and it is estimated that they contained some 10,000 tons of zinc. The proposal to erect a zinc distillation plant at Jamshedpur, near the works of the Tata Iron and Steel Company Limited, has, unfortunately, been abandoned. However, in the large tonnages of zinc-ore now proved to exist at Bawdwin, the country possesses not only sufficient to supply her own needs, but a surplus which will make her a very important factor in the world's supply when prices and conditions generally improve.

J, Coggin Brown: "Geology and Ore Deposits of the Bawdwin Mine". *Rec. Geol Surv. Ind.*, Vol. XLVIII, pp. 121-178, (1917).

J. Coggin Brown : "Notes on Zinc", *Bull. Ind. Inds. Lab.*, No. 19, (1921).

ZIRCON

Zircon is a silicate of zirconium and it is found as a common accessory mineral in many granites and gneisses. The sands derived from such crystalline rocks often contain small particles of the mineral. When it is large enough, perfectly transparent and sufficiently free from flaws, it is cut as a gem-stone and by reason of its high refractive index, is very lustrous and brilliant. In this form it is known as the hyacinth and is usually of a brownish shade of orange. The pale yellow and colourless varieties from Ceylon are called "jargoons" by jewellers. La Touche records small quantities of zircon in nepheline syenites near Kangayam in the Coimbatore district of Madras, but not of gem quality. Red and greyish-white crystals, transparent in parts, occur in pegmatite veins at Appiyode in the Eraniel taluk of Travancore. Fine crystals come from an unknown locality in the Vizagapatam district of Madras.

Large quantities of zircon, in the form of sand, are obtained as a by-product in the treatment of the beach sands of

Travancore for monazite, and small parcels have been shipped to Europe and America for experimental purposes. The mineral is used in the preparation of ferro-zirconium and other alloys, for which there is a small demand in the steel industry, and of the oxide, which is used as an opacifier in the manufacture of white and grey enamels for iron ware. The principal application of the mineral at present, however, is as a refractory lining for metallurgical and glass furnaces.

APPENDIX

INDIA'S MINERAL PRODUCTION IN 1922

(All outputs are given in tons unless otherwise stated)

Mineral	Quantity	Value Rs.	Value £
Alum	331	99,760	6,651
Amber	3.6 cwts.	1,960	131
Asbestos	242	10,520	701
Barytes	2,392	48,000	3,200
Bauxite	4,919	15,948	1,063
Building Materials ...	......	59,22,498	394,833
Chromite	22,777	3,61,287	24,086
Clays	104,748	2,73,272	18,218
Coal	19,010,986	14,63,30,145	9,755,343
Copper Ore	30,804	3,07,635	20,509
Diamonds	171,39 carats	91,648	6,110
Fullers' Earth	13,539	36,664	2,444
Gold	438,015 ozs.	2,78,63,479	1,857,565
Gypsum	40,645	64,479	4,298
Ilmenite	400	18,000	1,200
Iron Ore	625,274	15,66,430	104,428
Jadeite	7,805 cwts.	24,86,969	165,798 (a)
Lead Ore	172,066	1,41,77,053	945,137
Magnesite	19,273	2,40,692	16,046
Manganese ore	774,860	1,72,76,312	1,151,754 (a)
Mica	43,145 cwts.	57,85,245	385,683 (a)
Monazite	125	28,065	1,871
Ochre	6,702	57,180	3,812
Petroleum	298,504,125 gallons	10,77,75,652	7,185,043
Ruby	93,078 carats	6,45,304	43,020
Salt	1,653,898	1,22,88,270	819,218
Saltpetre	11,673	35,22,995	234,866
Sapphire	102,462 carats	76,045	5,070
Silver	4,244,304 ozs.	1,01,28,504	675,234
Spinel	35,620 carats	5,963	397
Steatite	906	36,395	2,426
Tin	218	5,33,395	35,560
Tin Ore	1,874	23,01,041	153,403
Wolfram	943	3,75,532	25,035
Zinc Ore	18,061	13,57,575	90,505 (a)
Zircon	160	19,200	1.280

(a) = export figures.

INDEX OF LOCALITIES

ASSAM

BALUCHISTAN

BENGAL

BURMA

CENTRAL INDIA AGENCY

CENTRAL PROVINCES

PUNJAB

RAJPUTANA

UNITED PROVINCES