RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

VOL. XXXII, PART 1.

1905.

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Part 2.—Geological notes on the route traversed by the Yarkand Embassy from Shah-i-Dula to Yarkhand and Kashgar. On the occurrence of jade in the Karakas valley, on the southern borders of Turkistan. Notes from the Eastern Himalaya. Petroleum in Assam. Coal in the Garo Hills. On the discovery of a new locality for copper in the Narbada valley. Potash-salt from East India. On the Geology of the neighbourhood of Mari hill station in the Punjab.

Part 3.—Geological observations made on a visit to the Chaderkul, Thian Shan range. On the former extension of glaciers within the Kangra district. On the building and ornamental stones of India. Second note on the materials for iron manufacture in the Raniganj coal-field. Manganese ore in the Wardha coal-field.

Part 4.—The auriferous rocks of the Dhambal hills, Dharwar district. Remarks on certain considerations adduced by Falconer in support of the antiquity of the human race in India. Geological notes made on a visit to the coal recently discovered in the country of the Luni Pathans, south-east corner of Afghanistan. Note on the progress of geological investigation in the Godavari district, Madras Presidency. Notes upon the subsidiary materials for artificial fuel.

Vol. VIII, 1875.

Part 1.—Annual report for 1874. The Altum-Artush considered from a geological point of view. On the evidences of 'ground-ice' in tropical India, during the Talchir period. Trials of Raniganj fire-bricks.

Part 2. (*out of print*).—On the gold-fields of south-east Wynaad, Madras Presidency. Geological notes on the Khareean hills in the Upper Punjab. On water-bearing strata of the Surat district. Sketch of the geology of Scindia's territories.

Part 3.—The Shahpur coal-field, with notice of coal explorations in the Narbada region. Note on coal recently found near Moflong, Khasia Hills.

Part 4.—Note on the geology of Nepal. The Raigarh and Hingir coal-fields.

Vol. IX, 1876.

Part 1 (*out of print*).—Annual report for 1875. On the geology of Sind.

Part 2.—The retirement of Dr. Oldham. On the age of some fossil floras in India. Description of a cranium of Stegodon Ganesa, with notes on the sub-genus and allied forms. Note upon the Sub-Himalayan series in the Jamu (Jummoo) Hills.

Part 3.—On the age of some fossil floras in India. On the geological age of certain groups comprised in the Gondwana series of India, and on the evidence they afford of distinct zoological and botanical terrestrial regions in ancient epochs. On the relations of the fossiliferous strata at Maleri and Kota, near Sironcha, C. P. On the fossil mammalian faunæ of India and Burma.

Part 4.—On the age of some fossil floras in India. On the osteology of Merycopotamus dissimilis. Addenda and Corrigenda to paper on tertiary mammalia. Occurrence of Plesiosaurus in India. On the geology of the Pir Panjal and neighbouring districts.

Vol. X, 1877.

Part 1.—Annual report for 1876. Geological notes on the Great Indian Desert between Sind and Rajputana. On the occurrence of the cretaceous genus Omphalia near Nameho lake, Tibet, about 75 miles north of Lhassa. On Estheria in the Gondwana formation. Notices of new and other vertebrata from Indian tertiary and secondary rocks. Description of a new Emydine from the upper tertiaries of the Northern Punjab. Observations on under-ground temperature.

Part 2.—On the rocks of the Lower Godavari. On the 'Atgarh Sandstones' near Cuttack. On fossil floras in India. Notices of new or rare mammals from the Siwaliks. On the Arvali series in North-eastern Rajputana. Borings for coal in India. On the geology of India.

Part 3.—On the tertiary zone and underlying rocks in the North-west Punjab. On fossil floras in India. On the occurrence of erratics in the Potwar. On recent coal explorations in the Darjiling district. Limestones in the neighbourhood of Barakar. On some forms of blowing-machine used by the smiths of Upper Assam. Analyses of Raniganj coals.

Part 4.—On the Geology of the Mahanadi basin and its vicinity. On the diamonds, gold, and lead ores of the Sambalpur district. Note on 'Eryon Comp. Barrovensis,' McCoy, from the Sripermatur group near Madras. On fossil floras in India. The Blaini group and the 'Central Gneiss' in the Simla Himalayas. Remarks on some statements in Mr. Wynne's paper on the tertiaries of the North-west Punjab. Note on the genera Chœromeryx and Rhagatherium.

Vol. XI, 1878.

Part 1.—Annual report for 1877. On the geology of the Upper Godavari basin, between the river Wardha and the Godavari, near the civil station of Sironcha. On the geology of Kashmir, Kishtwar, and Pangi. Notices of Siwalik mammals. The palæontological relations of the Gondwana system. On 'Remarks, &c., by Mr. Theobald upon erratics in the Punjab.'

Part 2.—On the Geology of Sind (second notice). On the origin of the Kumaun lakes. On a trip over the Milam Pass, Kumaun. The mud volcanoes of Ramri and Cheduba. On the mineral resources of Ramri, Cheduba, and the adjacent islands.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1905. [April.

GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA FOR THE PERIOD APRIL 1903 TO DECEMBER 1904. BY T. H. HOLLAND, F.R.S., *Director.*

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I.—INTRODUCTION.

Origin of the Review.

FOR the four years 1894 to 1897, a Review of the Mineral Production of India was issued annually by the Reporter on Economic Products; 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 sufficiently long to permit the determination of any decided secular variations in the mineral industry. The present Review, covering the period of six years, 1898 to 1903, is the first essay in this direction; but, in accordance with the orders of Government, five-year periods will be adopted for the future, and the Quinquennial Review of Mineral Production will be published in the Records of the Geological Survey of India.

In this review the minerals are grouped according to the system laid down by Government ten years ago, namely—

Group I.—Those for which approximately trustworthy returns are available; and

Group II.—Those regarding which definitely recurring particulars cannot be procured.

Grouping of the minerals.

In the first review, issued by Sir George Watt in 1894, the minerals referable to Group I included only Salt, Coal, Iron-ore, and Petroleum, and in the three subsequent issues of the same publication no advance was shown in transferring minerals from Group II to Group I. It is possible now, however, to raise several minerals to the level of those for which approximately trustworthy returns are available, and the minerals thus included in this group are:—

Coal.	Mica.
Gold.	Petroleum.
Graphite.	Rubies.
Iron-ore.	Salt.
Jadeite.	Saltpetre.
Magnesite.	Tin.
Manganese-ore.	

In the case of Gold, the most precise and elaborate details are obtainable for more than 99 per cent. of the production, and approximate values are obtainable for the rest. For Graphite, accurate returns of quantity are obtained from the only company engaged in regular mining for the mineral. Although the returns sent in for the production of Jadeite and Mica are manifestly understated, both minerals are worked largely for export, and, as far as value is concerned, the export figures may be accepted as an approximate estimate of the trade in each case, whilst the nature of the error being known, the figures are not liable to be misleading. Manganese-ore has come into prominence since the older reviews were issued, and may now be transferred to Group I, as the mineral is worked entirely for export, and the totals obtained from returns made by the District Officers agree very closely with those obtained from the ports. Rubies admit of the remarks applicable to Gold: the amount recovered other than by the Burma Ruby Mines Company may be neglected as an unimportant fraction of the total. Saltpetre and Tin are, with less certainty, entitled to places in this group. For Saltpetre, the returns for production are evidently understated, being less each year than the quantity exported, but the export figures may be taken as only slightly less than those for the production of refined Saltpetre. The returns for Tin refer to two districts only in South Burma, but the estimates are probably more reliable than those for Iron, which was originally included in Group I.

Missing minerals.

This Review is directed primarily to a survey of the progress already made, and for anything approaching an idea of the material awaiting development the reader must consult the Manual of Economic Geology, now in course of revision by the Geological Survey Department. But besides the substances whose existence has been determined by the exploratory work to which a geological survey is properly restricted with regard to minerals of economic value, the attention of prospectors might be directed to the minerals which have lately come into prominence through recent industrial developments, and which, in a country including the geological variety of India, are at present conspicuous by an absence that is probably only the result of absence of search. Amongst these are some minerals of the so-called rare metals, which, being generally of high specific gravity, should be searched for in the heavy concentrates of river gravels (see p. 114).

Unless otherwise specified, the ton is invariably taken in this Review to be the English statute ton, or the so-called long ton of 2,240 lbs. To facilitate comparison with the returns of foreign countries, many of the larger quantities are also calculated to metric tons of 1,000 kilogrammes each. As exchange has been steadily maintained at the rate of Rs.15 = £1 throughout the period under review, all values are expressed in terms of the sterling unit.

Units recognized.

The data employed in this Review have been mainly extracted from the publications issued by the Director-General of Statistics; but additional information has been obtained from the following sources:—

Sources of information.

(1) Annual Reports of the Gold Mining Companies on the Kolar field, kindly supplied by the Managing Agents.

(2) Annual Reports of the Chief Inspector of Mines for India and the Chief Inspector for Mysore.

(3) Administration Reports of the various Local Governments and Local Administrations in India.

(4) Administration Reports of the Railways.

(5) Reports issued by various foreign Geological Surveys, and Statistics relating to Mines and Quarries, published by the English Home Office.

The writer is also indebted to the Managing Agents of several mining companies for much information supplied direct, and he is especially indebted to Mr. J. A. Robertson, Director-General of Statistics, for assistance in analysing the data hitherto published only in consolidated tables.

II.—SUMMARY OF PROGRESS.

Total values.

THE following table summarizes the values of the principal minerals produced during the six years under review. The totals have the obvious defect of being due to the addition of unlike denominations; for export values, being the only returns obtainable in some cases, are ranged with spot values, while the latter necessarily vary with the position of the mine, representing not the *values*, but the *prices* obtainable. In the case of coal, for instance, the so-called value of a ton of good coal in Bengal is less than half that of the inferior material raised in Baluchistan or Burma; in the case of salt, the values given are the prices charged, and these, on an average, are but one-tenth of the duty, which is the principal value of the salt to Government; certain valuable mineral products, like building-stone, are omitted altogether for want of even approximate estimates.

The values returned for minerals exported are also necessarily lower than they would be if the minerals were consumed in the country, and it is consequently unfair to compare this table of values with corresponding returns for countries in which metallurgical industries flourish. Manganese-ore is a conspicuous example of a product which, according to its quality, may be worth 30 to 40 shillings a ton to the European steel-maker, but which is of less value to the Indian producer by the heavy cost of transport. The country is thus not only so much poorer by the loss of the metal exported in the ore, but is paid in return little more than half its market value.

The imperfections of the table are those confessedly inseparable from all such estimates of mineral production; and it is of use merely as a means of comparing one year with another, the same system being carried through the whole period under review. It will be seen that there has been, year by year, a steady, uninterrupted progress in production, from a total of £3,455,565 in 1898, to £4,988,527 in 1903—an increase of 44·37 per cent. in five years. To this total increase every mineral has contributed, except jadeite and amber, and for both of these the figures are of more doubtful value than for most of the other minerals.

TABLE I.—*Total Value of Minerals for which Returns of Production are available for the years 1898 to 1903.*

MINERALS.	1898.	1899.	1900.	1901.	1902.	1903.	*Average.*
	£	£	£	£	£	£	£
Gold	1,608,504	1,724,906	1,891,767	1,930,411	1,970,230	2,302,493	*1,904,719*
Coal (*a*)	957,162	1,063,820	1,343,081	1,323,372	1,366,909	1,299,716	*1,225,677*
Salt (*b*)	358,933	312,682	325,970	409,019	344,633	336,147	*347,897*
Saltpetre (*c*)	265,896	232,896	256,210	294,249	237,880	288,487	*262,603*
Petroleum (*a*)	67,897	125,684	148,755	200,342	217,816	354,365	*185,810*
Rubies	57,950	90,848	97,326	104,476	86,895	98,575	*89,345*
Mica (*c*)	53,890	73,372	109,554	70,034	87,594	86,277	*80,120*
Manganese-ore	27,426	39,529	77,304	79,119	120,538	132,741	*79,443*
Jadestone (*c*)	41,780	42,120	58,955	46,377	31,713	47,676	*44,770*
Iron-ore (*e*)	12,403	12,836	11,171	13,598	16,533	14,963	*13,584*
Graphite (*d*)	110	7,620	9,145	13,635	24,410	16,970	*11,981*
Tin	2,553	7,900	8,534	7,773	5,340	9,153	*6,875*
Magnesite (*d*)	...	56	150	...	2,360	550	*519*
Amber	1,061	151	103	11	432	414	*362*
TOTAL	**3,455,565**	**3,734,420**	**4,338,025**	**4,492,416**	**4,513,283**	**4,988,527**	*4,253,705*

(*a*) Spot prices. (*c*) Export values.
(*b*) Prices without duty. (*d*) Estimated values.
(*e*) Estimated values for provinces other than Bengal.

General character of the minerals worked.

On looking over the returns for mineral production in India for the past six years, two features stand out most conspicuously. Firstly, there has been a remarkable progress in developing the few minerals which are consumed by what conveniently might be called direct processes, such as Coal, Gold, Petroleum, Gem-stones, and Salt, or which are raised for simple export, such as Manganese-ore, Graphite, Saltpetre, Mica, and Tin. Secondly, there has been an equally remarkable neglect of the metalliferous ores and the minerals which are necessary to the more complicated chemical and metallurgical industries.

The neglect of metalliferous ores.

The principal reason for the neglect of metalliferous minerals is the fact that in modern metallurgical and chemical developments the bye-product has come to be a serious and indispensable item in the sources of profit, and the failure to utilize the bye-products necessarily involves neglect of the minerals which will not pay to work for the metal alone. Copper sulphide ores are conspicuous examples of the kind: many of the most profitable copper mines in the World could not be worked but for the demand for sulphur in sulphuric acid manufacture, and for sulphuric acid there would be no demand but for a string of other chemical industries in which it is used (*cf.* page 117). A country like India must be content, therefore, to pay the tax of imports until industries arise demanding a sufficient number of chemical products to complete an economic cycle, for chemical and metallurgical industries are essentially gregarious in their habits.

Value of mineral imports.

An examination of our import statistics shows how far the domestic production falls short of the requirements of the country in minerals and mineral products. During the three years 1901-1903 the average annual value of these imports was £10,158,252, and this figure does not include the value of glassware, earthenware, porcelain, machinery, railway material, hardware, and the innumerable articles which, though made from metals known to exist in India, have values greatly in excess of the raw materials used in their manufacture, and which, in any case, would be partly made elsewhere. Of the average annual total, 54·7 per cent., or £5,559,511, was paid for metals alone.

Summary for the Minerals of Group I.

Coal.

In the case of Coal, the Indian output has risen from a little over 4 million tons in 1897 to 7½ million tons in 1903, and within the period under review, India, for the first, though probably also for the only, time, secured the leading place as a coal-producer amongst British dependencies. Of the total output, the Bengal coal-mines contributed the chief, and an annually increasing, fraction, from 78·6 per cent. in 1898 to 85·5 per cent. of the total in 1903. On account of the fact that very little development has occurred in metallurgical industries, the coal consumption of India is not likely greatly to exceed that of Australia, and will certainly fall behind that of Canada, until our metalliferous ores, and especially those of iron, are raised for smelting in the country.

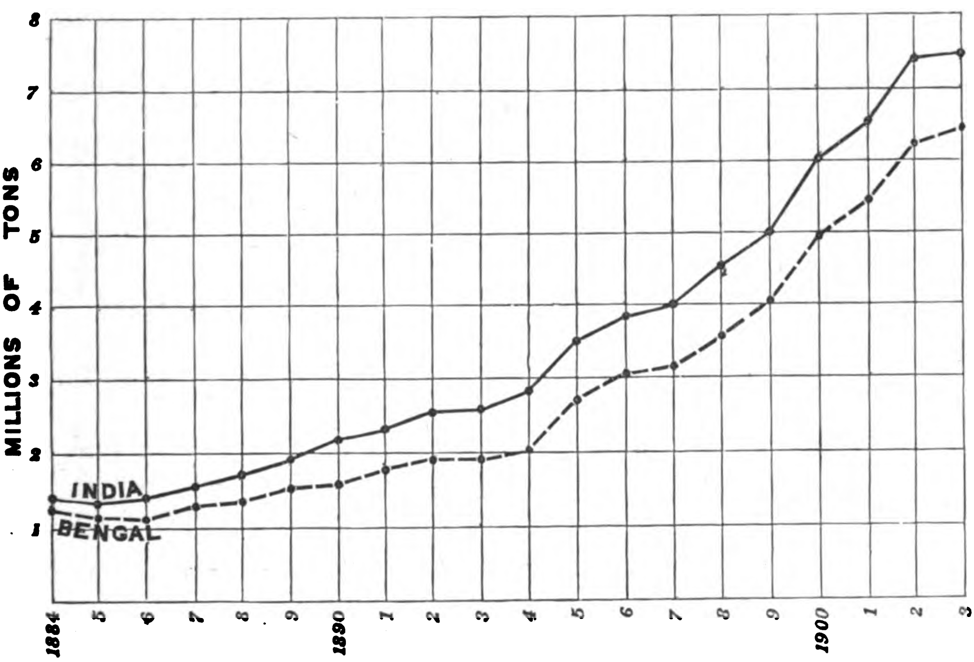


FIG. 1.—*Production of Coal for 20 years.*

As far as they go in their small way, it is satisfactory, from the coal-miners' point of view, to observe that, within the period under review, the figures for imports and exports have become reversed, with every sign of permanency in their present relative positions (figure 2, page 10).

Another feature of the coal trade—which is satisfactory also to those with wider interests than the coal-miner—is the fact that whilst the railways have reduced their purchases of foreign coal to the dimensions of mere samples—as shown graphically in figure 3 (page 11)—and whilst their total coal bill has been steadily increasing, they have been, at the same time, taking year by year a gradually shrinking fraction of the total output of the mines—a fact which indicates that other coal-consuming, industrial enterprises have developed at a greater rate than railway expansion.

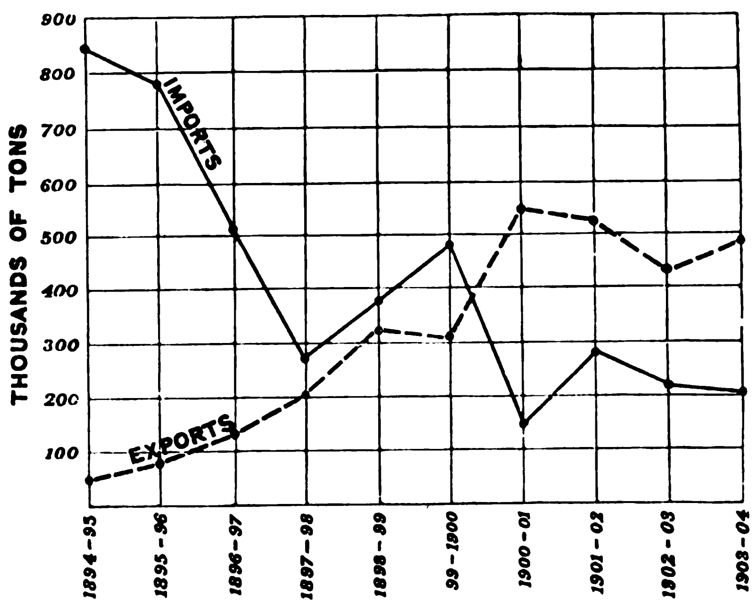


FIG. 2.—*Exports and Imports of Coal for the past 10 years.*

Gold.

The production of Gold has shown a steady increase, from a total of 390,595 ounces, valued at £1,568,065, in 1897, to 603,218 ounces, valued at £2,302,492, in 1903. The progress since 1890 is shown in figure 4 (page 12).

By far the largest fraction of the output has been obtained from a single reef in the Kolar field, Mysore State, but promising work in reef-mining has recently been commenced in the Nizam's Dominions and in the Dharwar district, Bombay Presidency, whilst preparations are being made for an extension of dredging operations on the gravels of the Upper Irawadi river in Burma.

Graphite.

Amongst the minerals which have been taken up more seriously during the period under review, the Graphite of Travancore and the Magnesite of Salem in Madras are noticeable. The Graphite raised during the three years

1901 to 1903 averaged 3,486 tons per annum, which is quite a serious item in the comparatively small market of this mineral. The total annual production of graphite in the World varies between 70,000 and 80,000 tons, and the Indian output is thus about 4½ per cent. of the total quantity raised, but its value is not returned, and is estimated in the summary table at £5 a ton.

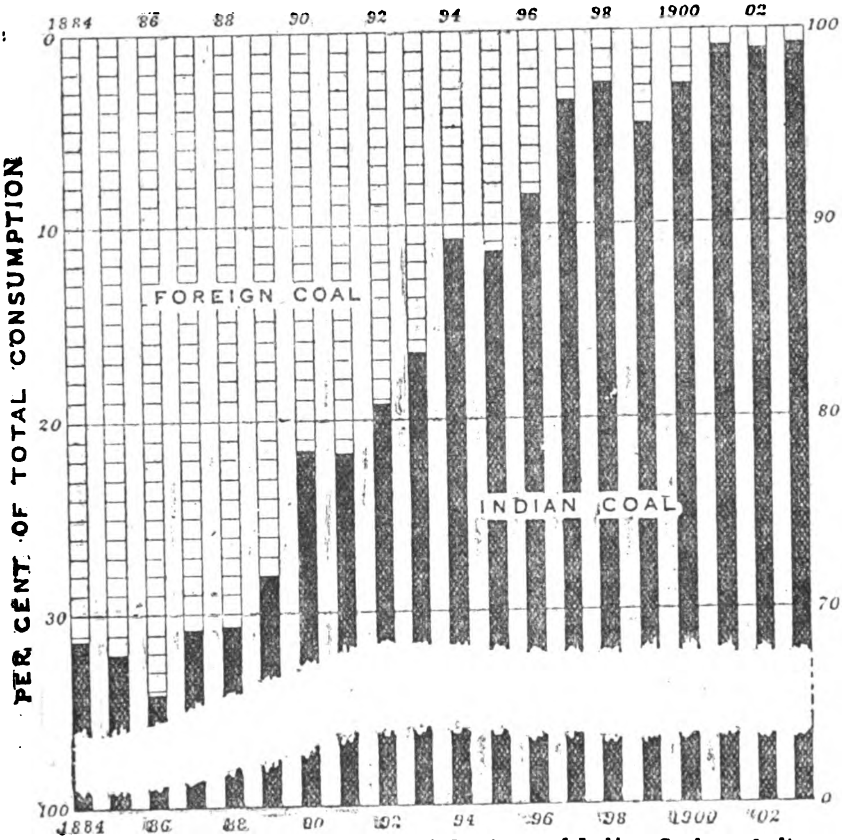


FIG. 3.—*The relative Consumption of Foreign and Indian Coals on Indian Railways during the 20 years 1884 to 1903.*

The works at Barakar still remain as the one successful attempt to manufacture Iron along European lines in India. Prospecting operations on an extensive scale have been carried on recently in the Central Provinces, the results in one area being unfavourable and in the other undetermined. There is a general decline in the native charcoal-iron industry within range of the railways

Iron.

which distribute the cheap imported material, but in more remote parts of the Peninsula the old industry persists, and in parts of the Central Provinces has even improved. In the Sambalpur district there are over 200 small direct-process furnaces still at work.

During the six years under review the average annual value of iron and steel imported was £3,078,065, but as this does not include the amounts brought in in the form of machinery, the figures would present a very different appearance if workshops and foundries were more widely developed in India. As the imports of iron and steel have been rising year by year, and were valued at £4,136,184 in 1903, the figures, as far as they go, are quite sufficient to show that there is room in the country for a large iron-manufacturing industry, which would soon bring in its train the manufacture of machinery.

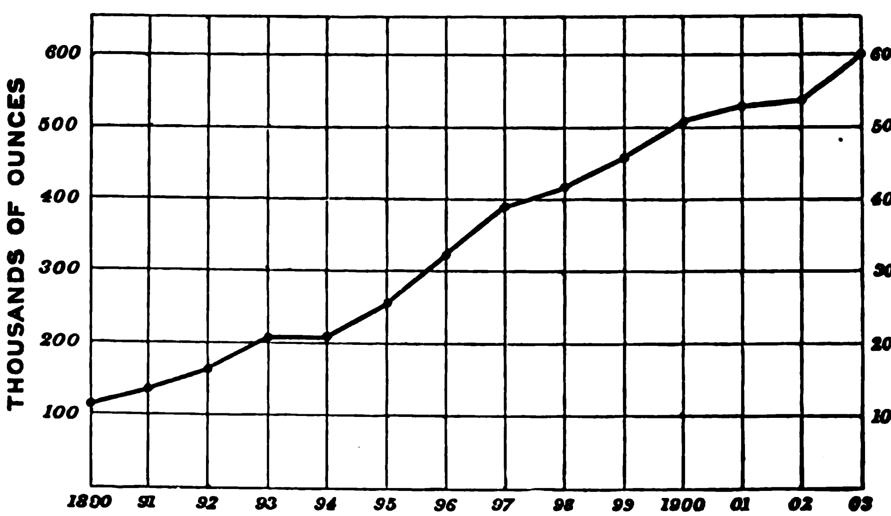


FIG. 4.—*Production of Gold since 1890.*

Jadeite. From the fact that the district returns for production show little more than half the quantities of "Jadestone" declared in the export statistics, it is evident that less interest is taken in the mineral than its value appears to justify. With an average annual value of £44,770 returned for the exports to the Straits and China, jadeite should be ranked amongst the important minerals, its value being nearly seven times that of the tin turned out and nearly half that of rubies.

Magnesite. Magnesite-mining was hardly established before the close of 1903, but preparations on a large scale are now being made to open up the well-known deposits near Salem, in which the mineral occurs in a condition of exceptional purity.

Manganese-ore. The rapid rise of Manganese-ore mining is probably just now the most conspicuous feature in the mineral industry of India. Twelve years ago the industry had not definitely started, whilst last year India turned out a larger quantity of high-grade ores than any country except Russia. The diagram forming figure 5 shows that, within the period under review, work commenced in the Central Provinces, and on account of the high degree of richness and purity of the ore-bodies there opened up, production rapidly developed, in spite of the handicap of a railway journey of 500 to 600 miles between the mines and the coast. The recent discovery of deposits in the Bombay Presidency nearer the coast will probably result in a still further expansion of the export trade, which, however, in view of the unlimited fuel supplies lying idle in India, and the annually increasing bill for imported steel, cannot be regarded with unmixed satisfaction.

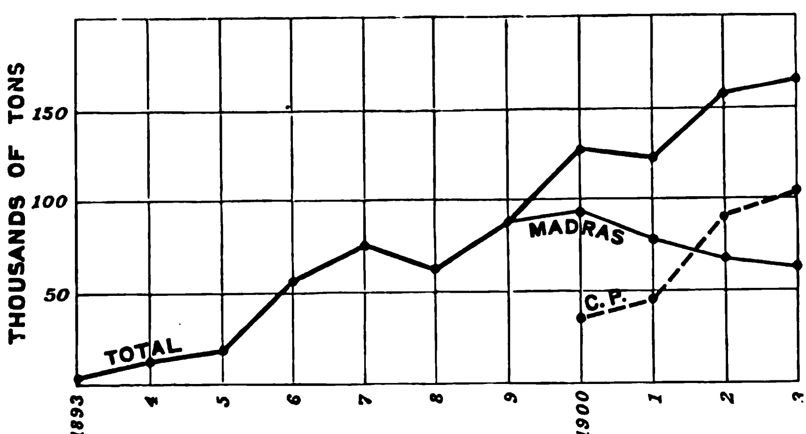


FIG. 5.—*Production of Manganese-ore since the commencement in 1893.*

Mica. Although India is still the leading producer, and is supplying something like half the World's wants in Mica, the miner in India has not secured a satisfactorily large share of the recently increased trade in this mineral, and the returns for India show a smaller degree of expansion than those for consumption in Europe and America.

Figure 6, showing the fluctuations in total weight and total value of the mica exported, demonstrates in an interesting way the change which took place in the ratio of the two, when, near the beginning of the period under review, the Indian mica-miners began to turn over their waste heaps to supply the demand for the cheaper "flimsy" mica required for the newly-invented micanite.

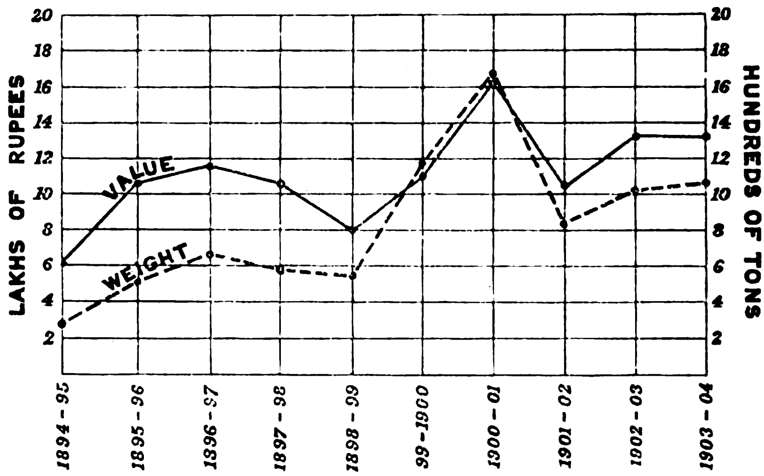


FIG. 6.—*Exports of Indian Mica during the past 10 years.*

Petroleum. The Petroleum industry has increased at a greater rate even than coal-mining. From a production of just 19 million gallons in 1897, the output rose to nearly 88 million gallons in 1903, and in addition to the export of considerable quantities of paraffin wax, the illuminating oils and petrol refined in Burma and Assam have at last shown signs of definitely displacing foreign supplies in the Indian market (figure 7, page 15).

Rubies. Next to Petroleum, Rubies now form the chief source of revenue amongst mineral products in Burma, the Ruby-Mining Company under the new lease having entered a favourable phase after a long period of uncertainty in its prospects. The Company paid its first dividend of 5 per cent. in 1898, and continued to work with greater profits in 1899 and the following years.

Salt. The production of Salt has shown considerable fluctuations, from 1,102,039 tons in 1901 to 823,184 tons in 1903, the average annual production for India, exclusive of Aden, having been 979,572 tons for the period under review. Of this amount 61·8 per cent. was obtained from sea-water, 27 per cent. was obtained from sub-soil brine and from lakes in areas of internal drainage, whilst the remainder, 11·2 per cent., was raised from the rock-salt deposits in the Punjab and North-West Frontier Province. The average annual import of foreign salt amounted to 433,754 tons, of which 89·8 per cent. was imported to Bengal, and 10·1 per cent. entered Burma.

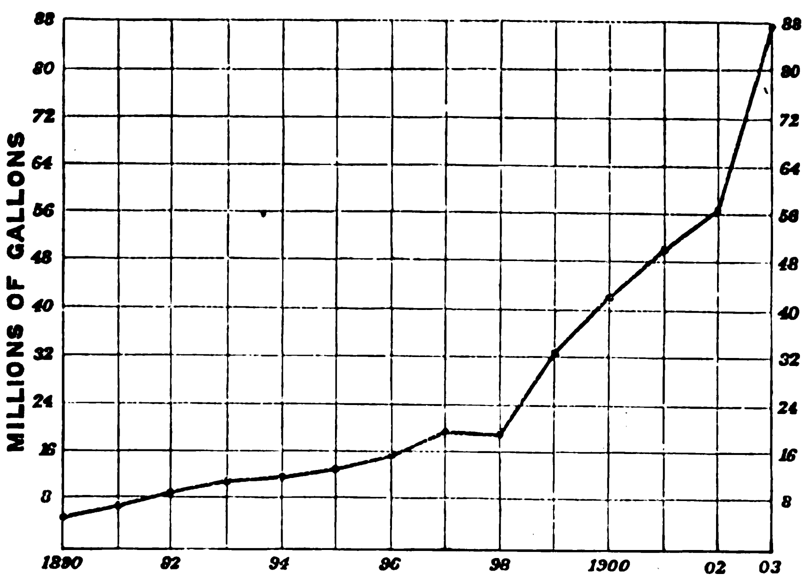


FIG. 7.—*Production of Petroleum since 1890.*

Saltpetre.

The production of Saltpetre is evidently understated, being considerably below the quantities returned as exports. The average annual exports for the six years amounted to 382,353 cwt., of which 30·7 per cent. went to the United Kingdom, 25·7 per cent. to Hong-Kong, and 24·0 per cent. was exported to the United States. Most of the saltpetre was manufactured in Behar, and 98·5 per cent. of the total left India through the port of Calcutta. The only trans-frontier trade of importance is the import of saltpetre from Nepal, the average annual amount for the period under review being 9,417 cwts.

Tin.

Although Tin-mining in South Burma is still practised on a small scale, there has been a marked improvement in the returns, and the persistently high price of tin is likely to inspire more enterprise in the exploitation of these deposits, which are a natural continuation of those in the Malay Peninsula, from which more than half the World's supply is obtained.

III.—DETAILED ACCOUNT OF THE MINERALS OF GROUP I.

Coal.

DURING the period of six years under review, the output of Coal rose from a total of 4,066,294 tons in 1897 to 7,438,386 tons in 1903, an increase of 83 per cent. (table 2). The expansion was, however, mostly confined to the first five years of this period, as in 1903 the production exceeded that of 1902 by only 13,906 tons.

Progress in output.

TABLE 2.—*Production of Coal during the years 1898 to 1903.*

YEAR.	Quantity.	Total value at the place of production.	*Average value per ton at the mines.*
	Tons.	Rupees.	*Rupees.*
1898	4,608,196	1,43,57,436	3·12
1899	5,093,260	1,59,57,301	3·13
1900	6,118,692	2,01,46,222	3·29
1901	6,635,727	1,98,50,582	2·99
1902	7,424,480	2,05,03,639	2·76
1903	7,438,386	1,94,95,741	2·62

From this table it will be noticed that during the latter half of the period under review supplies began to exceed the demand, and lower prices, on an average, were accepted. The average *prices* paid for coal at the pit's mouth are rather unfairly stated as *values*, but the figures are nevertheless interesting as indications of the rates at which coal can be raised with profit. The average rate given as Rs. 2·76 (3*s*. 8*d*.) in 1902 was much

Prices.

below that of most coal-producing countries of the same year. The following table shows the declared pit-mouth value in some other countries for 1902 :—

Countries.	Per ton.	Countries.	Per ton.
	s. d.		*s. d.*
United Kingdom . .	8 2¾	Australia . . .	7 9
Germany	8 10¼	New Zealand . . .	10 0
United States . . .	5 8¼	Canada	9 3

Comparison of India with Canada and Australia.

A reference to table 3 will show that in 1902 India, for the first time, secured the leading place as a coal-producer amongst the British dependencies, although the amount of coal raised was only 2·95 per cent. of the total for the British Empire in the same year, and only 0·94 per cent. of the World's total output. The figures are not mere curiosities to those who know the leading conditions affecting production. In 1895 Canada produced more coal than India, but India then began to supply the eastern steamship companies in consequence of the high prices produced by the English colliers' strikes of the two preceding years, and for the first time the returns for 1896 showed that India was leading as coal-producer, but was still well behind Australia. Australia was overtaken in 1902, and India thus enjoyed the first place; but it is unlikely that this position will be occupied for more than the one year, and the returns for 1903, when published, will probably show India giving way, not to Australia, but to Canada. If this prove to be true, the causes will be worth the attention of those interested in Indian coal-mining. Canada for many years was a small producer of iron and steel, and its rich deposits of iron-ore in the region of the Great Lakes, where Canadian territory is without coal deposits, were worked for export to the adjoining States of the American Union. In 1900 the total production of pig-iron in Canada amounted to 86,090 tons and of steel 23,577 tons only; but iron and steel works were started in the chief coal-producing colony, Nova Scotia, at the end of 1901, and the result is a reported production of 319,557 tons of pig-iron and 182,037 tons of steel for 1902. Iron and steel-making, more than most manufacturing industries, creates a market for coal, and if this industry flourishes in Canada, India will resume its second place as a coal-producer until its resources in iron-ore can, in the same way, be utilized for the consumption of coal. Australia at present is, like India, dependent for most of its iron supplies from outside sources, and, like India, must depend on other industries and on exports for a coal market.

TABLE 3.—*Production of Coal in the three large British Dependencies.*

COUNTRIES.	1898.		1899.		1900.		1901.		1902.	
	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*	Metric tons.	*Per cent. of British output.*
Australia .	5,490,776	2·49	5,539,382	2·31	6,479,991	2·61	7,000,227	2·86	6,968,514	2·72
Canada .	3,785,372	1·72	4,142,202	1·73	4,837,291	1·95	5,612,108	2·29	6,930,220	2·71
India .	4,203,199	1·91	5,016,390	2·09	6,216,882	2·51	6,742,214	2·76	7,543,625	2·95
TOTAL for British Empire.	220,301,426		239,995,148		247,938,725		244,463,996		256,003,411	

Relation of consumption to production.

The market for Indian coal must be limited to (1) its own home industries, and (2) the Indian Ocean ports, where the manufacturing industries requiring coal are comparatively few, and where India is not the sole supplier of fuel. Tables 4 and 6 show that during the last six years India consumed on an average 93·1 per cent. of the coal produced in the country, and, in addition, imported annually on an average 298,940 tons of foreign coal, which must have been, in calorific value, very little below the slightly larger quantity of Indian coal sent out of the country during the same period.

The actual annual increment of consumption since 1897 has been, on an average, 509,919 tons a year, whilst the increment of production during the same period has averaged 562,015 tons. As the figures for consumption and production do not differ seriously, the great expansion which has taken place in the Indian coal trade must have been made possible by industrial developments in India itself. The next few years will show whether this expansion is a correct index to the development of other industries, or whether it is the result mainly of increased facilities of transport and of consequent access to new markets.

TABLE 4.—*Relation of Consumption to Production.*

YEAR.	Total consumption of coal in India.	CONSUMPTION OF INDIAN COAL IN INDIA.(*a*)	
		Quantity.	*Percentage of Indian production.*
	Tons.	Tons.	
1898 . . .	4,650,154	4,280,929	92·9
1899 . . .	5,269,563	4,788,373	94·1
1900 . . .	5,719,136	5,576,669	91·1
1901 . . .	6,396,466	6,110,680	92·1
1902 . . .	7,221,241	6,992,679	94·2
1903 . . .	7,189,167	6,996,438	94·1
Average .	*6,075,954*	*5,790,961*	*93·1*

(*a*) The consumption of coal is assumed to be production *plus* imports *minus* exports. In the exports a ton of coke is taken to be equivalent to 1½ tons coal required for its production. The imports include Government stores.

Consumption of coal on Indian railways.

The railways in India have consumed on an average 29·7 per cent. of the coal produced during the past six years and table 5 shows that there has been a slight tendency for the consumption of Indian coal on the railways to form a gradually smaller fraction of the output from the mines. This is probably not merely a temporary effect, as the figures for a corresponding period ten years back, namely, 1888 to 1893, show, when treated in the same way, that the consumption of Indian coal on the railways averaged at that time 32·6 of the production. As the differences between exports and imports have been, on an average, insufficient to affect seriously the figures for total coal consumption, and as the railways in India now consume a smaller percentage of the output than in former years, the expansion in Indian coal production may be regarded as a partial measure of the expansion of other industrial enterprises. It is not a complete measure of such expansion, as new markets have been found in recent years for Indian coal; and as probably most of the available markets have been entered now, the rate of increase in production in the future will be more nearly limited to the rate of expansion in the industries of the country. For this reason, the future of Indian coal-mining would be brighter if there were a prospect here, as in Canada, of a sensible development of the metallurgical industries; these are the real consumers of coal, and it is only when they are developed in India that the expansion in coal-mining will make a serious inroad into the enormous supplies of coal available in the country.

TABLE 5.—*Coal consumed on Indian Railways during the years 1898 to 1903.*

YEAR.	INDIAN COAL.			FOREIGN COAL.		TOTAL Consumption.
	Quantity.	*Per cent. of Total.*	Per cent. of Indian output.	Quantity.	*Per cent. of Total.*	
	Tons.			Tons.		Tons.
1898 . . .	1,422,103	97·3	30·9	39,004	2·7	1,461,107
1899 . . .	1,557,000	95·0	30·6	82,446	5·0	1,639,446
1900 . . .	1,855,610	97·2	30·3	54,339	2·8	1,909,949
1901 . . .	1,956,601	99·3	29·5	13,248	0·7	1,969,849
1902 . . .	2,091,992	99·0	28·2	21,469	1 0	2,113,461
1903 . . .	2 203,889	99·2	29·6	17,696	0·8	2,221,585
Average .	*1,847,866*	...	*29·7*	...	...	...

The country is now rapidly assuming the position of supplying its whole wants in mineral fuel. Table 6 and figure 2 (page 10) show that the imports of foreign coal for all purposes have been gradually diminishing,

Foreign coal on Indian railways.

whilst table 5 and figure 3 show that on the railways foreign coal has been almost entirely cut out. Twenty years ago the foreign coal consumed on the railways amounted to 31 per cent. of the total; ten years ago this was reduced to 10·7 per cent., whilst during the past six years the foreign coal has averaged 2·16 per cent. of the supplies to the railways, and during the last three years this has been reduced to under 1 per cent. In other words, twenty years ago foreign coal was a serious item in the fuel supplies of the railways: it is now imported in mere samples.

Imports and exports.

The interchange of positions, which has occurred between exports and imports during the last 20 years, is clearly shown in figure 2, and in more detail on plate 1. The actual reversal has occurred within the period under review, as shown in table 6.

TABLE 6.—*Imports and Exports of Coal during the years 1897-98 to 1902-03, including Government Stores.*(*a*)

YEAR.	Imports.	Exports.
	Tons.	Tons.
1897-98	276,487	213,146
1898-99	379,225	327,267
1899-00	481,190	304,887
1900-01	142,467	542,023
1901-02	285,786	525,047
1902-03	228,562	431,831
Average .	*298,940*	*390,695*

(*a*) The figures include coke and patent fuel, each ton of coke being counted as 1½ tons of coal.

It is important to observe, with regard to both imports and exports, that the reversal of position, although it looks striking when expressed in diagrammatic form, has taken place on comparatively small quantities, both being insignificant beside the production and consumption within India itself.

Imports.

The countries from which foreign coal supplies have been obtained are shown in table 7, from which it will be seen that the principal portion of the supplies has been obtained from Great Britain, and that practically all of the remainder has come from Australia and Japan.

TABLE 7.—*Origin of Imported Coal, Coke, and Patent Fuel.*

YEAR.	United Kingdom.	Australia.	Japan.	Other Countries.	TOTAL.
	Tons.	Tons.	Tons.	Tons.	Tons.
1897-98 . .	245,555	16,406	14,213	233	276,407
1898-99 . .	326,794	18,778	32,281	1,372	379,225
1899-00 . .	375,269	20,282	82,936	2,703	481,190
1900-01 . .	98,315	14,638	27,967	1,547	142,467
1901-02 . .	211,327	19,685	53,440	1,334	285,786
1902-03 . .	210,904	6,237	6,975	4,446	228,562
Average .	*244,694*	*16,005*	*36,302*	*1,939*	*298,940*

Exports.

The distribution of exported Indian coal is shown in table 8, from which it will be seen that Ceylon and the Straits Settlements have taken the principal share, the averages for the six years being 246,352 tons of coal in the case of Ceylon and 85,095 tons in the case of the Straits, the returns for coke being of small importance.

Possible expansion of the export trade.

The variations in exports to the two chief customers are shown graphically on plate 1. Of the causes which led to the decline in the exports to Ceylon during the last three years, one has been reported to be the unfavourable reputation earned by the shipment of inferior coal to meet the increased demands made in 1900. If this is the case, the cure is in the hands of the Bengal coal-owners, for the demand must have been no real strain on the supplies available, and the figures given in table 9 will show that the markets of Ceylon and Singapore are both large enough to be worth the serious attention of Indian coal-shippers.

TABLE 8.—*Exports of Indian Coal.*

—	1897-98.	1898-99.	1899-00.	1900-01.	1901-02.	1902-03.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Aden	8,094	14,416	4,000	53,305	47,194	21,214	*24,704*
British East Africa	3,619	150	...	20,569	16,922	11,562	*8,804*
Ceylon	104,524	214,986	180,909	368,031	335,651	274,010	*246,352*
Mauritius	7,317	2,708	18,128	5,759	18,745	14,690	*11,224*
Natal	...	287	6,072	598	160	2,324	*1,573*
Straits Settlements	85,280	93,462	86,951	65,715	89,592	89,567	*85,095*
Sumatra	...	...	3,531	10,863	10,690	14,655	*6,623*
Other Places	3,439	769	4,392	15,450	5,012	3,032	*5,349*
TOTAL Exports	**212,273**	**326,778**	**303,983**	**540,290**	**523,966**	**431,054**	**389,724**
VALUE	£ 142,283	£ 223,100	£ 217,776	£ 393,889	£ 375,977	£ 257,968	£ 268,499

TABLE 9.—*Foreign Coal Imports of Ceylon and Singapore for the years 1901 to 1903.*(*a*)

ORIGIN OF THE COAL.	CEYLON.			SINGAPORE.		
	1901.	1902.	1903.	1901.	1902.	1903.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
England	286,842	288,362	246,500	60,419	50,984	52,500
Japan	6,300	...	26,400	433,548	370,426	400,000
Australia	5,522	3,752	12,200	38,965	36,087	44,500

(*a*) For Indian coal sent to Ceylon and Singapore, see table 8.

Practically all the coal exported leaves by the port of Calcutta, which, being the nearest port to the Bengal coal-fields, is the centre of distribution to the other ports of India. The quantity exported from Calcutta during the past six years is shown in table 10 to have averaged 1,622,686 tons, with the two highest records in 1901 and 1903 and a distinct general increase from the year 1898 onwards.

Calcutta exports.

TABLE 10.—*Coal shipped from Calcutta during the years 1898 to 1903.*

—	1898.	1899.	1900.	1901.	1902.	1903.	*Average.*
To Foreign Ports .	314,562	269,112	488,555	587,100	428,995	438,975	*421,216*
„ Indian Ports .	906,509	867,161	1,245,996	1,407,913	1,257,528	1,513,711	*1,201,470*
TOTAL .	**1,221,071**	**1,136,273**	**1,734,551**	**1,995,013**	**1,696,523**	**1,952,686**	*1,622,686*

Of Indian ports, Bombay is by far the most important market for Bengal coal, having, during the period under report, taken on an average 679,445 tons a year, with a maximum of 881,806 tons in the last year, 1903. The amount of Bengal coal taken at Bombay is now well beyond the foreign imports, which, during the same period, averaged 192,237 tons, by far the largest fraction having come from the United Kingdom.

The distribution of Bengal coal to Indian ports is shown in table 11, on page 26, from which it will be seen that the places of importance after Bombay have been, in order, Rangoon, Madras, Karachi, Cuddalore, and Negapatam.

Table 12 (page 27) shows that amongst the provinces Bengal occupies the leading position as a coal-producer, whilst a glance at figure 1 (page 9) will show that the Bengal output is not only the largest part, but has been a yearly increasing fraction of the total, the contribution having risen from 78·6 per cent. in 1898 to 85·5 per cent. in 1903. Three coal-fields in Bengal, namely, Raniganj, Jherria, and Giridih, have yielded nearly all the coal hitherto credited to Bengal, but the Daltonganj field, which is now connected with the East Indian Railway system, has recently been opened up by the Bengal Coal Company.

Production by provinces.

TABLE 11.—*Distribution of Bengal Coal to Indian Ports.*

PLACES.	1898.	1899.	1900	1901.	1902.	1903.	*Average.*
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	*Tons.*
Akyab . .	1,614	2,167	5,575	6,160	9,745	2,293	*4,592*
Balasore . .	2,681	219	4	...	...	13	*486*
Bassein . .	...	4,622	3,900	7,221	15,112	9,852	(*b*) *8,141*
Bhownagar .	...	...	...	...	...	15,690	(*a*) *15,690*
Bombay . .	449,302	399,121	824,080	861,859	660,504	881,806	*679,445*
Chandbali . .	6,985	1,875	625	465	192	212	*1,726*
Chittagong .	785	2,671	3,791	3,637	2,288	3,374	*2,758*
Cocanada . .	100	...	...	4,226	...	1,000	*888*
Cuddalore . .	22,635	28,706	12,088	31,591	21,492	33,293	*24,968*
Karachi . .	20,801	...	4,730	14,108	84,825	54,824	*29,881*
Kyaukpyu . .	473	514	605	497	181	40	*385*
Madras . .	193,102	193,667	136,189	173,171	150,850	170,760	*169,623*
Mandapam . .	...	...	...	...	...	13,974	(*a*) *13,974*
Marmagoa . .	...	...	...	...	...	14,380	(*a*) *14,380*
Moulmein . .	1,359	1,120	2,270	1,338	3,571	1,619	*1,879*
Negapatam .	24,226	18,930	28,199	31,009	23,754	21,557	*24,613*
Pondicherry .	...	6,120	3,994	10,088	7,571	5,000	(*b*) *6,555*
Port Blair . .	750	1,000	1,000	750	6,000	6,009	*2,585*
Rangoon . .	169,979	188,619	209,469	242,777	261,213	264,344	*222,734*
Tuticorin . .	10,677	17,007	9,237	18,285	12,505	12,918	*13,438*
Other Ports .	1,040	803	240	731	7,725	753	*1,882*
TOTAL .	**906,509**	**867,161**	**1,245,996**	**1,407,913**	**1,267,528**	**1,513,711**	*1,201,470*

(*a*) One year only. | (*b*) Average for 1899 to 1903 only.

TABLE 12.—*Output of Indian Coal by Provinces for the years 1898 to 1903.*

YEAR.	Assam.	Balu-chistan.	Bengal.	Burma.	Central India.	Central Provinces.	Hyderabad.	Punjab and Kashmir.	Rajpu-tana.	TOTAL.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1898	200,329	13,372	3,622,090	6,975	134,726	149,709	394,622	85,862	511	4,608,196
1899	225,623	15,822	4,035,265	8,105	164,569	156,576	401,216	81,835	4,249	5,093,260
1900	216,736	23,281	4,978,492	10,228	164,489	172,842	469,291	74,083	9,250	6,118,692
1901	254,100	24,656	5,487,585	12,466	164,362	191,516	421,218	67,730	12,094	6,635,727
1902	221,096	33,889	6,259,236	13,302	171,538	196,981	455,424	56,511	16,503	7,424,480
1903	239,328	46,909	6,361,212	9,306	193,277	159,154	362,733	44,703	21,764	7,438,386

Geological origin of the coal.

Most of the coal raised has been obtained from the Gondwana system of strata in Peninsular India, where the coal-mines, being nearer the coast, and generally within touch of the main railway lines, have been developed more rapidly than those of the Extra-Peninsular Cretaceous and Tertiary coal-beds (table 13).

TABLE 13.—*Origin of Indian Coal raised during the years 1898 to 1903.*

YEAR.	FROM GONDWANA STRATA.		FROM TERTIARY STRATA.		TOTAL production.
	Tons.	*Per cent. of Total.*	Tons.	*Per cent. of Total.*	Tons.
1898	4,301,147	*93·4*	307,049	*6·6*	4,608,196
1899	4,757,626	*93·4*	335,634	*6·6*	5,093,260
1900	5,785,114	*94·6*	333,578	*5·4*	6,118,692
1901	6,264,681	*94·4*	371,046	*5·6*	6,635,727
1902	7,083,179	*95·4*	341,301	*4·6*	7,424,480
1903	7,076,376	*95·1*	362,010	*4·9*	7,438,386
Average .	*5,878,021*	*94·5*	*341,769*	*5·5*	6,219,790

The Gondwana coalfields.

The contribution from the Gondwana coal-fields in 1898 amounted to 93·4 per cent. of the total output for the year. This increased to 95·1 per cent. in 1903, whilst the average for the whole period of six years has been 94·5 per cent. Comparing 1898 with 1903, there has been an increased output in all the Peninsular Gondwana fields, except in the case of Singareni, where the rapid expansion which had been going on without interruption until 1902 was suddenly checked by a serious mining accident in June 1903, and a consequent drop in the year's output from 455,424 tons in 1902 to 362,733 tons in 1903. In the case of the Extra-Peninsular fields, there has also been an increase, though a much smaller one, in all the provinces, except in the Punjab, where the Dandot colliery in the Salt Range, which has been the chief producer, has been gradually failing (*cf.* table 17, page 35).

TABLE 14.—*Output of Gondwana Coalfields for the years 1898 to 1903.*

COALFIELD.	1898.	1899.	1900.	1901.	1902.	1903.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Bengal:—						
Daling . .	2,191	2,098	1,490	...	...	...
Daltonganj . .	...	...	707	3,881	19,352	33,557
Giridih . .	653,047	628,777	712,727	694,806	776,656	766,871
Jherria . .	749,988	1,007,236	1,710,757	1,946,763	2,420,786	2,493,729
Rajmahal . .	423	412	397	436	219	335
Raniganj . .	2,216,441	2,396,742	2,552,414	2,841,699	3,042,283	3,066,720
Central India:—						
Umaria and Johilla	134,726	164,569	164,489	164,362	171,538	193,477
Central Provinces:—						
Mohpani . .	22,472	23,596	39,612	43,046	43,645	31,443
Pench valley .	...	...	...	...	...	88
Warora . .	127,237	132,980	133,230	148,470	153,336	127,623
Hyderabad:—						
Singareni . .	394,622	401,216	469,291	421,218	455,424	362,733
TOTAL Gondwana beds .	4,301,147	4,757,626	5,785,114	6,264,681	7,083,179	7,076,376

Raniganj and Jherria.

Taking the Gondwana areas first, we find that the Raniganj field, which was the first to be developed, still holds the lead (see table 14), having turned out 41·2 per cent. of the total production for India in 1903. Jherria, further west in the Damuda valley, is, however, rapidly overtaking Raniganj since its railway connection to the capital by the East Indian line has been supplemented by a branch from the Bengal-Nagpur system. In 1897 Jherria contributed only 8·2 per cent. of the Indian output, whilst in the last year, 1903, the production of this field amounted to 33·5 per cent. of the total.

The coal from the Raniganj field is mainly derived from seams in the highest beds of the Damuda series, the lowest, or Barakar stage, being less developed in the exposures along the northern margin of the field. In the Jherria field the converse is the case: the uppermost stage has yielded poor coal, whilst in the Barakar series there are some eighteen well-defined seams, of which the upper eight seams include enormous supplies of good coal. The two classes of coal present a well-marked and constant difference in the amount of moisture they contain: the older, Barakar, coals, both in the Raniganj field and in Jherria, contain on an average about 1 per cent. of moisture, whilst the average for the younger coal of the Raniganj series is 3·8 per cent. in the lower seams, and nearly 7 per cent in the upper seams. There is a corresponding, but less marked, difference in the proportion of volatile hydrocarbons, which form a larger percentage of the younger coals than of those at lower stages in the Damuda series.

Giridih.

The small patch of coal-bearing Gondwana rocks near Giridih is practically divided between the Bengal Coal and the East Indian Railway Companies. The chief wealth of the field is stored in a 15-foot seam of good steam and coking coal near the base of the Damuda series. This coal has the following average composition:—

Fixed carbon	66·4
Volatile matter	24·4
Ash	9·2

The output of the field, which is controlled largely by the requirements of the railway company, has been rising gradually during the last six years from 660,665 tons in 1897 to 766,871 tons in 1903, and the remaining workable supplies probably do not exceed 77 million tons. A proposal for introducing modern methods of coke-making with a view to the recovery of the valuable bye-products is now being considered by the East Indian Railway Company.[1]

[1] T. H. Ward: Modern methods of coke-making. Rec. Geol. Surv. Ind., vol. XXXI, 92 (1904).

The other principal coal-fields being worked on the Peninsula are, Warora, Mohpani, and those of the Pench valley in the Central Provinces, Umaria in the Rewah State, and Singareni in the Nizam's Dominions.

Pench valley.

In the Pench valley and the belt of related coal-bearing Gondwana rocks dipping under the Satpura range, only prospecting work has been done so far; but favourable results have been obtained by locomotive trials on samples of the coal, and the proximity of the fields to the great manganese-ore deposits, and (when connected by direct rail to Nagpur or Itarsi) to the markets of Bombay and the mills of the Deccan, will give these deposits an opportunity of developing whatever intrinsic merits they possess.

Mohpani.

The coal-bearing rocks which dip under the Upper Gondwanas of the Satpura range re-appear near Mohpani in the Narsinghpur district, where they have just escaped total concealment by the Narbada alluvium. The Mohpani colliery has been worked since 1862 by the Nerbudda Coal and Iron Company, and, through various difficulties, has made very little progress. Between the years 1898 and 1903 the annual output from this colliery rose from 22,472 to 43,645 tons during the first five years, but a drop occurred in 1903, due to the final abandonment of the old mines and the development of work in the newly-discovered area two miles further west.

Warora.

The Warora basin, about 62 miles south of Nagpur, in the Chanda district, has been worked since 1871 by the State. About half the coal raised, which averaged 137,146 tons a year for the years 1898 to 1903, has been taken by the Great Indian Peninsular Railway, the rest going to cotton mills and factories in Nagpur and other parts of the Central Provinces. The coal is liable to spontaneous combustion, and a large part of the field has been lost by fire and walled-off. The Warora colliery has been worked under distinctly greater natural difficulties than those usually met with in Bengal, but an examination of the chief results obtained by the present able management will probably be of value to those interested in Indian coal-mining. Table 15 shows the financial results of the past six years' working of the colliery. These results are shown graphically in relation to coal output on plate 3.

TABLE 15.—*Financial Results of the Warora Colliery during the years 1898 to 1903.*

YEAR.	Gross earnings.	Working expenses.	FINANCIAL RESULT.	
			Net earnings.	*Percentage on Capital.*
	£	£	£	
1898	39,719	28,247	11,472	*9·58*
1899	40,193	27,661	12,532	*10·96*
1900	40,507	26,939	13,568	*12·22*
1901	46,085	28,875	17,210	*15·90*
1902	46,669	29,267	17,402	*17·11*
1903	39,499	26,616	12,883	*13·16*

The average selling price of coal at Warora during the past six years has been Rs. 4-7 a ton, and the average cost of its production during the same period has been Rs. 3-1-5, of which a considerable fraction is due to charges for the sinking fund. This cost has been distributed as follows :—

	Annas
***Mine Working Expenses*—**	
Superintendence	3·24
Coal-cutting	12·85
Underground haulage, including maintenance of shafts, roads and working ways, with repairs	9·87
Surface haulage, including lighting and maintenance of permanent way	1·25
Pumping	7·54
Ventilation	1·65
Staff-quarters and other buildings	0·42
Miscellaneous	1·52
***Management and Office Expenses*—**	
Local Offices, Police, Medical and India Office charges	3·07
Sinking Fund charges	8·01
TOTAL .	49·42 annas.

The returns for labour at Warora, notwithstanding the difficulties arising from water and liability to spontaneous combustion, show that the system of mining adopted permits of a satisfactory output per person employed, whilst the deaths due to accidents have been reduced to a low rate. During the six years, 1898 to 1903, the average annual output of coal per person employed was 132 tons, whilst there were four deaths only during the period in which 822,876 tons of coal were raised, and the death-rate from mining accidents averaged 0·64 per 1,000 employed. Another three or four years will probably see the end of the Warora colliery, but, with the extension of the Wardha valley line southwards, the extensive deposits near Bellarpur will be opened up.

Singareni.

The great belt of Gondwana rocks, near the north-west end of which Warora is situated, stretches down the Godavari valley as far as Rajamundry, and at one or two places the equivalents of the coal-bearing Damuda series in Bengal are found cropping up from below the Upper Gondwana rocks. One of these occurrences near Yellandu in the Nizam's Dominions forms the coalfield well known by the name of Singareni. The principal seam of coal, some 5 to 6 feet thick, being worked at the Singareni colliery, was discovered by the late Dr. W. King of the Geological Survey in 1872, but mining operations were not commenced until 1886, since when the output has rapidly risen to over 400,000 tons a year, although the production last year, 1903, showed a decline to 362,733 tons, owing to a serious subsidence in one of the workings (see table 14 and plate 2).

Coal-mining at Singareni has been accompanied by a heavier loss of life by accidents than in the general run of Gondwana fields. Table 16 shows the death-rate on this field compared with the rate in Bengal.

TABLE 16.—*Death-rate from Accidents at Singareni compared with Bengal.*

	—	1898.	1899.	1900.	1901.	1902.	1903.	*Average.*
SINGARENI.	Number of persons employed.	6,788	8,450	8,045	7,616	7,538	6,359	*7,473*
	Deaths from accidents .	9	8	9	12	17	29	*14*
	Death-rate per 1,000 employed.	1·33	0·94	1·12	1·58	2·25	4·56	*1·87*
Death-rate in Bengal coal-fields		*0·45*	*0·52*	*0·60*	*0·53*	*0·53*	*0·85*	*0·58*

D

The Bilaspur-Katni Branch of the Bengal-Nagpur Railway passes through the small coalfield of Umaria in the Rewah State, Central India. The quantity of workable coal in this field is estimated at about 24 million tons, and during the past six years the output has been gradually rising from 134,726 tons in 1898 to 193,277 in 1903 (see table 14, and plate 2). The four coal seams being worked vary from about 3 to 12 feet in thickness, and dip about 4° to the north-east. The mines were opened in 1882 under the direction of Mr. T. W. H. Hughes of the Geological Survey, and were controlled by Government until the 1st January 1900, when they were handed over to the Rewah State. Most of the coal raised is sold to the Indian Midland (Great Indian Peninsular) Railway, and a small quantity to the Bengal Nagpur Railway and other customers.

Umaria.

Cretaceous and Tertiary Coalfields.

The younger coals are nearly all of Cretaceous and Tertiary age, although some thin and poor seams of Upper Jurassic coal have been worked in Cutch. The Cretaceous beds occur in the Khasia and Garo hills in Assam, where they are found in small basins resting on the Archæan schists and gneisses. The Cretaceous coals of Assam are generally distinguished by the inclusion in them of nests of fossil resin, and this character was noticed in the coal recently discovered to the north of Shillong.[1]

Coal of Tertiary age is found in Sind, Rajputana, Baluchistan, along the foot-hills of the Himalayas, further east in Assam, in Burma, and in the Andaman and Nicobar Islands. The most frequent occurrence is in association with nummulitic limestones, though the richest deposits, namely, those in North-East Assam, are younger, probably miocene, in age. Of these Extra-Peninsular fields, the only ones producing coal are of Tertiary age. The output for each of these for the years 1898 to 1903 is shown in table 17 (page 35).

On the whole, the younger coals, which are being worked in Extra-Peninsular areas, differ from the Gondwana coals in containing a larger proportion of moisture and volatile hydrocarbons, and though as variable in composition as they are in thickness of seam, coals are obtained,

[1] P. N. Bose: Report on the Um-Rileng coal-beds, Assam. Rec. Geol. Surv. Ind., XXXI, 35 (1904).

as for instance in Assam, with a remarkably low percentage of ash and having a high calorific value.

TABLE 17.—*Production of Tertiary Coal during the years 1898 to 1903.*

Province and field.	1898.	1899.	1900.	1901.	1902.	1903.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
Assam :—						
Makum	202,178	232,933	215,962	254,100	220,640	239,328
Smaller fields . .	1,367	807	774	...	456	...
Baluchistan :—						
Khost	10,662	11,689	17,664	18,431	25,982	36,444
Sor Range and Mach .	5	265	5,617	6,225	7,907	10,465
Burma :—						
Shwebo: Thingadaw .	6,975	8,105	10,228	12,466	13,302	9,306
Kashmir :—						
Ladda	...	...	...	...	1,138	999
Punjab :—						
Dandot . . .	74,590	81,218	74,083	67,730	55,373	43,704
Other mines . . .	11,272	617	...	...	...	...
Rajputana :—						
Bikaner . . .	...	...	9,250	12,094	16,503	21,764
TOTAL for Tertiary beds .	307,049	335,634	333,578	371,046	341,301	362,010

North-East Assam.

The most promising amongst these young coals is the group of occurrences in North-East Assam, one of which is now being worked by the Assam Railways and Trading Company, who commenced operations at Makum (27°15′; 95°45′) in 1881. The collieries are connected by a metre-gauge railway with Dibrugarh on the Brahmaputra river, which, being navigable, forms both a market and a means of transport for the coal. The most valuable seams occur between the Tirap and Namdang streams, where, for a distance of about five miles, the seams vary from 15 to 75 feet in thickness. The average dip is 40°, but as the outcrops in many places are several hundred feet above the plains, facilities exist for working the coal by adit levels. The average coal production of the Makum mines during the last six years has been 227,523 tons a year. The coal has the reputation of being a good fuel, and forms an excellent coke.

Shwebo district, Burma.

Coal occurs in various parts of Burma, and in the Shwebo district the annual output during the years 1898 to 1903 varied between 6,975 and 13,302 tons without signs of expansion. The only point worth adding to previously published accounts of the Burma coal is the fact that during the past year it has been definitely ascertained that in the Nammaw field, which is some 30 miles from the Mandalay-Lashio Railway line, the existence of seams of good coal, 10 feet thick, has been recently verified by the Geological Survey. This and the Lashio field, further north in the Northern Shan States, are likely to be of importance to the new railway lines in that area.

Baluchistan, Khost.

Possibly the most important of the coal deposits in the west occur in Baluchistan, where, however, the disturbed state of the rocks renders mining operations difficult, expensive, and often dangerous. Besides the small mines being worked in the Sor range, south-east of Quetta, and in the Bolan pass at Mach, collieries have been worked since 1877 at Khost (30° 12′; 67°40′) on the Sind-Pishin Railway. The two seams being worked have an average thickness respectively of 26 and 57 inches, and the output has gradually risen from 10,662 tons in 1898 to 36,444 tons in 1903.

To the natural difficulties of the ground is added a serious scarcity of trained labour, and as a consequence the working results of these mines appear to be unfavourable when compared with the exceptional conditions existing on the Gondwana fields of Peninsular India. Table 18 (on page 37) shows the financial results of the undertaking, which is under the control of the North Western State Railway.

The output per person employed at Khost has averaged only 44 tons per annum during the past six years, and the difficulties of the work are further shown by the fact that the death-rate from mining accidents has been, in the same period, 23·2 per thousand persons employed; but of this serious loss of life, 47 out of a total of 64 deaths were caused on October 12th, 1899, by a fire in the Takrai mine. Besides the stratigraphical difficulties arising from working the Tertiary coal seams, which are often irregular in thickness and lie in disturbed, uncertain ground, there are additional dangers due to the liability of most of these pyritous coals to spontaneous combustion, and to the danger of explosions by the large quantities of dust generally formed in working such friable coals.

TABLE 18.—*Summary of the Financial Results of Working the Khost Colliery during the years 1898 to 1903.*

YEAR.	Gross earnings.	Working expenses.	FINANCIAL RESULT.	
			Net earnings.	*Percentage on capital.*
	£	£	£	
1898	9,423	8,371	1,052	25·00
1899	10,482	11,334	−852	...
1900	16,290	14,443	1,847	19·11
1901	14,500	11,379	3,121	22·77
1902	18,509	17,266	1,243	7·01
1903	23,804	19,978	3,826	17·02

Dandot.

The coal which has been most worked in the Punjab is that long known to exist in the Jhelum district, on the Dandot plateau of the Salt range. The only valuable seam varies in thickness from 18 to 39 inches, forming a basin under the nummulitic limestone. The mines at Dandot and at Pidh, 3 miles to the north-east, have been worked for the North Western Railway since 1884. During the period under review, 1898 to 1903, the collieries have shown a decline in output, from a maximum of 81,218 tons in 1899 to 43,704 tons in 1903, and during the last two years the mines have been worked at a loss. The annual output of coal per miner employed at Dandot during the last six years has averaged only 42 tons, against about 75 tons turned out per man in Bengal; but notwithstanding the difficulties connected with mining in this area, the loss of life through accident has been as low, on an average, as 0·74 per 1,000 employés.

Bhaganwala.

The coal near Bhaganwala at the eastern end of the Salt range occurs in a seam of very variable thickness, in consequence of which widely discordant estimates have been made of the resources of the field. Between 1893 and 1898 the field was worked by the North-Western Railway, but the quality of the fuel was poor, and the collieries were worked at a loss. The output amounted to 11,272 tons in 1898, when arrangements were made to dismantle the colliery, which was closed on the 15th January 1899.

Mianwali district.

Some minor works, not beyond the scale of ordinary prospecting operations, have been conducted on the deposits of Jurassic coal in the Mianwali district. The deposits about 2 miles north of Kalabagh are estimated to contain about 72,000 tons of coal, of which less than 1,000 tons a year are extracted. More promising deposits of Tertiary coal occur in the Maidan range, 24 miles further west, but no mining in this locality has so far been attempted.

Bikaner.

A lignite of dark-brown colour, with included lumps of fossil resin, occurs in association with nummulitic rocks at Palana in the Bikaner State, Rajputana. In 1898 mining operations were started at a point where the seam was found to be 20 feet thick, and a branch line, 10 miles long, from the Jodhpur Bikaner Railway, has been constructed to assist the development of the colliery. The figures given in table 17 show a gradual increase of output since 1900, the returns for 1903 being 21,764 tons. The physical characters of the natural fuel form a drawback to its use in locomotives, but experiments recently made are said to show that satisfactory briquettes can be made in which the proportion of moisture is reduced, and the fuel made less vulnerable to atmospheric action.

Labour.

Coal-mining in India, from the point of view of labour, is quite ahead of all other forms of mining. The number of persons employed daily has averaged 84,805 for the years 1898 to 1903, but the returns for 1903 show 9,872 less workers than in 1902, although the output of coal has risen (see table 19). This difference is possibly in part due to a gradually increased precision in the system of making returns, and partly, no doubt, to the fact that the introduction of improved methods in mining is gradually increasing the average efficiency of the miner;

but the sudden rise to an output of 84 tons per person employed, shown in table 20 for the year 1903, is so much in excess of the Giridih return of 72 tons, that there is probably some fault in the returns made of persons employed.

Table 19 shows that 81·8 per cent. of the average number employed during the period have worked in Bengal coal mines, and that the changes elsewhere have been insignificant beside the rise in Bengal from 48,673 in 1898 to 74,538 in 1903.

TABLE 19.—*Number of Persons employed daily in Indian Coal-Mining during the years 1898 to 1903.*

PROVINCE.	1898.	1899.	1900.	1901.	1902.	1903.	*Average.*	Per cent. of average total.
Assam	1,439	1,444	1,350	1,210	1,293	1,255	*1,332*	1·56
Baluchistan	238	310	493	635	828	843	*558*	·66
Bengal	48,673	58,130	72,790	79,620	82,545	74,538	*69,383*	81·80
Burma	315	230	279	203	170	80	*213*	·25
Central India	1,931	2,354	2,214	2,126	1,723	1,670	*2,003*	2·35
Central Provinces	1,711	1,852	2,104	2,220	2,337	2,071	*2,049*	2·41
Nizam's Dominions	6,788	8,490	8,045	7,616	7,538	6,359	*7,473*	8·80
Punjab and Kashmir	1,879	1,640	1,826	1,536	1,742	1,621	*1,707*	2·01
Rajputana	...	...	147	152	136	93	*(a) 132*	·16
TOTAL	**62,974**	**74,450**	**89,248**	**95,318**	**98,312**	**88,530**	*84,805*	**100·00**

(*a*) Average of three years only.

Effect of coal-mining on the population.

In the parts of Bengal where coal-mining has especially developed, the changes in the population of certain revenue areas since the Census of 1891 have been quite remarkable. The Census of 1901 showed that in the Giridih sub-division of the Hazaribagh district, there had been an increase of 4·0 per cent., part of which, in the Ganwan and Koderma *thánas*, was due to mica-mining, whilst in the Giridih *thána* the increase in ten years was 8·8 per cent. In the Gobindpur sub-division of Manbhum district, which includes much of the Jherria field, the increase of population between 1891 and 1901 was 25·1 per cent., whilst in the Jherria *thána* itself the increase was 75·1 per cent., and in the adjoining *thána* of Topchanchi the increase, from the same cause, was 30·2 per cent.

Efficiency of the Indian collier.

It will not be surprising to those who know the habits of the Indian coal-miner to learn that the output per person employed is lower than in any part of the British Empire except in Cape Colony, where cheap native labour is largely employed. During the years 1901 and 1902 the outputs of coal per person employed in Indian mines were respectively 70 and 75 tons, whilst for the rest of the British Empire the corresponding figures were 281 and 285 tons (see table 21).

TABLE 20.—*Output of Coal per Person employed at Indian Collieries.*

	1898.	1899.	1900.	1901.	1902.	1903.
Number employed	62,974	74,450	89,248	95,318	98,312	88,530
Tons of coal raised.	4,608,196	5,093,260	6,118,692	6,635,727	7,424,480	7,438,386
Tons of coal raised per person employed.	73	68	69	70	75	84

Death-rate from accidents.

An important consideration, naturally, in every mining community is the risk to life involved in the occupation. As far as coal-mining is concerned in India, the industry, so far as it has progressed, has shown not only a very low death-rate from isolated accidents, but also a noteworthy freedom from disasters, which in European countries have done more, perhaps, than statistics to force special legislation for the protection of workers in "dangerous" occupations. Table 22 shows, for the period 1898 to 1903, the number of deaths from coal-mining accidents in India, compared with the amount of coal raised and the number of persons employed. It will be seen from this table that the average death-rate from such accidents has been 0·88 per thousand employed, which will compare favourably with the returns for any other country.

TABLE 21.—*Amount of Coal raised per Person employed at Coal Mines in the British Empire.*

COUNTRIES.	1901.			1902.		
	Persons employed.	Tons of coal raised.	Tons per person.	Persons employed.	Tons of coal raised.	Tons per person.
United Kingdom .	792,648	219,046,945	276	810,787	227,095,042	280
New South Wales .	12,191	5,968,426	490	12,815	5,942,011	464
Queensland . .	1,266	539,472	426	1,336	501,531	375
Victoria . .	827	209,329	253	1,303	225,164	172
British Columbia .	3,974	1,460,331	367	4,011	1,397,394	348
Nova Scotia . .	7,663	3,625,365	473	8,062	4,366,869	542
Cape Colony . .	2,588	183,759	71	2,196	165,557	75
Natal . . .	3,397	569,200	168	3,850	592,821	154
New Zealand . .	2,754	1,227,638	446	2,885	1,362,702	472
Transvaal . .	..	...	...	5,439	1,590,330	292
British Empire except India . . .	**827,308**	**232,830,465**	**281**	**852,684**	**243,239,421**	**285**
India . . .	95,318	6,635,727	70	98,312	7,424,480	75

In table 23 (page 43) the results for the rest of the British Empire for the years 1901 and 1902 (the latest years for which complete figures are obtainable) are compared with the corresponding years for India. It will be seen from this that India competes with Queensland for the lowest death-rate, and that the average rate for the rest of the Empire is 1·53 and 1·54 against 0·73 and 0·77 for India. The rate will also compare favourably with the principal foreign coal-mining countries: in Austria the rates for 1901 and 1902 were 1·39 and 1·60 per thousand respectively; in Germany 2·22 and 1·93; in Belgium 1·02 and 1·07; in France 1·21 and 1·09; in Holland 1·47 and 1·27; and in the United States 3·10 and 3·25.

TABLE 22.—*Production of Coal compared with Deaths from Coal-Mining Accidents in India.*

—	1898.	1899.	1900	1901.	1902.	1903.	*Average.*
Deaths from coal-mining accidents	43	98	62	70	76	97	*74*
Thousands of tons of coal raised for each life lost . .	107	52	99	95	98	77	*84*
Lives lost per million tons of coal raised	9·3	19·2	10·1	10·5	10·2	13·0	*1·20*
Death-rate per thousand persons employed . . .	0·68	1·32	0·69	0·73	0·77	1·10	*0·88*

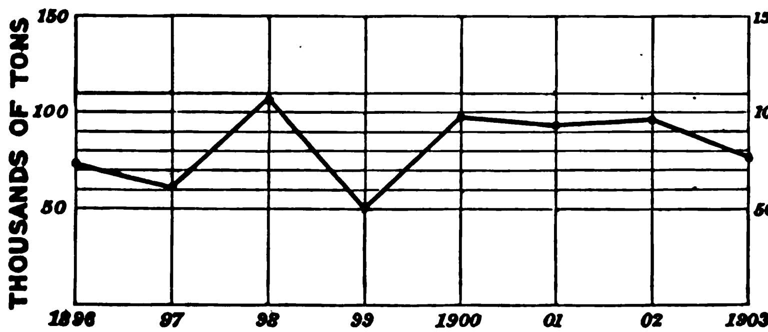


FIG. 8.—*Production of Coal per Life lost by Coal-mining Accidents.*

But the small output per person employed in India produces a far less favourable picture when we count the cost of a million tons of coal in lives lost by mining accidents. On this score it will be seen from table 23 that whilst in the years 1901 and 1902 the average numbers of lives lost per million tons of coal raised in the rest of the British

Empire were respectively 5·42 and 5·41, in India the loss in the same years came to 10·55 and 10·23. It will be noticed, however, that in India the number of persons employed in coal-mining is many times greater than in any part of the Empire, except the United Kingdom itself, where the large number of coal-miners, near 800,000, and the yearly output of more than 220 million tons of coal, together control and tone-out all the irregularities in the returns from the dependencies.

TABLE 23.—*Death-rate from Coal-Mining Accidents in the British Empire.*

	1901.				1902.			
	Number employed.	Deaths.	*Death-rate per 1,000.*	Deaths per 1,000,000 tons coal raised.	Number employed.	Deaths.	*Death-rate per 1,000*	Deaths per 1,000,000 tons coal raised.
United Kingdom.	792,648	1,075	*1·36*	4·91	810,787	1,005	*1·24*	4·42
New South Wales	12,191	17	*1·37*	2·85	12,815	105	*8·01*	17·67
Queensland .	1,266	1	*0·79*	1 85	1,336	1	*0·75*	1·99
Victoria .	827	4	*4·84*	19·11	1,303	1	*0·77*	4·44
New Zealand .	2,754	3	*1·09*	2·44	2,885	2	*0·69*	1·47
British Columbia	3,974	102	*25·67*	69·87	4,011	139	*34·65*	99·48
Nova Scotia .	7,663	14	*1·83*	3·86	8,062	19	*2·36*	4·35
Cape Colony .	2,588	4	*1·55*	21·77	2,196	4	*1·82*	24·16
Natal . .	3,397	43	*12·66*	75·54	3,850	16	*4·16*	26·99
Transvaal . .	...	...	...	...	5,439	23	*4·23*	14·47
British Empire except India .	**827,308**	**1,263**	**1·53**	**5·42**	**852,684**	**1,315**	**1·54**	**5·41**
India . .	95,318	70	*0·73*	10·55	98,312	76	*0·77*	10·23

The results for the coal-mines under the control of the Indian Mines Act of 1901 are slightly more favourable than for the total. For the three years during which the Act has been in operation the average death-rates from accidents at coal-mines under the Act have been as follows:—

1901	0·68	per 1,000.
1902	0·66	"
1903	0·84	"

Mining methods.

The almost universal practice in Indian coal-mines is to extract the coal on the system variously known as the "bord and pillar," "post and stall," or "stoop and room" system. Although this system in Europe is fast being superseded by the more economical "long-wall" method, yet, owing to the thickness of most of the Indian seams, it is not easy to devise any more suitable plan of working. It is undoubtedly wasteful, for the pillars form from 25 to 65 per cent. of the available coal, and at the present time, except in certain mines, where local-trained labour and efficient supervision are possible, their extraction is not even contemplated.

The strong roof so frequently found in the mines worked in Gondwana rocks, due, not only to the intrinsic strength of the rocks, but to the remarkable freedom from geotectonic disturbances on the Peninsula, adds a feature of strength and safety not at once fully appreciated by those who have gained their experience in countries without these advantages, or where the galleries are subject to the stresses of a greater overburden.

In the Giridih coal-field, the system of working thick seams at the East Indian Railway collieries permits of the removal of over 90 per cent. of the coal. As the system here carried out has been subject to careful criticism by English colliery experts, and as it has been shown that the system is perfectly safe under the efficient standard of management and discipline observed at Giridih, workers in other fields are recommended to study the account given by Mr. T. Adamson in his paper on the "Working of a thick coal-seam in Bengal," (*Trans. Min. and Mech. Engineers*, vol. LII, p. 202, 1903).

The system described by Mr. Adamson has been worked for the last twelve years in the Railway Company's collieries at Giridih without a fatal accident being caused by it, but the sandstone roof is an unusually strong one and the coal is free of gas. During the past six years, 1898 to 1903, the average death-rate from accidents of all kinds in these mines has been only 0·40 per thousand persons employed.

The figures given in table 23 for other coal-mining countries will give an idea of the remarkable degree of efficiency in management which this figure indicates.

In the Makum field a highly inclined seam, 75 feet thick, is worked on a modification of the South Staffordshire system of "square work." The coal is removed in two, or sometimes three, sections, the top section being removed first, and a parting of stone and coal being left untouched between each pair of sections. In the Dandot and Khost mines, thin seams are worked in one operation, on a modified "long-wall" system.

Gold.[1]

Comparison with other countries.

India, as shown in table 24, occupies the sixth or seventh position amongst the leading gold-producing countries of the World. The total Indian output is nevertheless comparatively insignificant, aggregating no more than 3½ per cent. of the World's annual supply.

TABLE 24.—*Production, in Ounces, of the Chief Gold-producing Countries for the years 1897 to 1902.*

COUNTRIES.	1897.	1898.	1899.	1900.	1901.	1902.
United States .	2,864,576	3,148,642	3,391,196	3,781,310	3 805,500	3,870,000
Australasia (a) .	2,539,491	3,013,763	3,831,937	3,568,279	3,719,103	3,989,083
Canada . .	291,583	662,796	1,018,371	1,350,176	1,183,465	1,003,447
Transvaal. .	2,744,010	3,777,009	3,529,826	348,760	238,991	1,704,410
Russia . .	1,042,017	1,196,634	1,159,214	1,072,434	1,253,592	1,183,379
India . .	390,595	418,944	456,020	512,985	532,126	517,639
Mexico . .	344,518	398,487	448,832	455,204	499,725	546,373
China . .	321,296	21,296	321,510	208,031	145,138	193,517
Korea . .	52,927	55,432	70,954	87,882	111,272	217,706
Brazil . .	70,736	76,613	107,644	127,820	133,636	146,898

(a) Includes the six States and New Zealand.

[1] This note on gold has been prepared mainly by my colleague, Mr. J. Malcolm Maclaren, B.Sc., F.G.S.

Table 25 shows the provincial production for India. In 1903 no less than 99¼ per cent. of the Indian output was returned by Mysore. Three-fourths of the remainder was derived from the Nizam's Dominions, leaving only ·18 per cent. as the produce of districts directly under British administration.

TABLE 25.—*Value of Gold produced during the years 1898 to 1903.*

	1898.	1899.	1900.	1901.	1902.	1903.
	£	£	£	£	£	£
Mysore	1,575,966	1,678,463	1,879,085	1,923,081	1,969,442	2,283,999
Nizam's Dominions . .	11,620	33,335	9,375	...	...	14,505
Burma	4,115	4,386	3,327	7,606	5,894	3,988
Madras	10,993	1,261	17	...	...	...
TOTAL (a) .	1,602,694	1,717,445	1,891,804	1,930,687	1,975,336	2,302,492

(a) Exclusive of small quantities obtained by river-washing in various provinces for which accurate returns are not available.

Development of the Kolar Field.

The produce of the Mysore State is solely derived from the Kolar district, and from a single vein or reef in that district—a reef averaging only some four feet in thickness, and payably auriferous for a distance of little more than four miles. As has been the case with all other known auriferous deposits in Peninsular India, the attention of Europeans was directed to this vein by the numerous old native workings along its strike. During the Wainad gold "boom" of 1878-82, several companies with huge capitals were floated to work portions of a concession over the Kolar field. Of the capital subscribed the greater portion was devoted to purchase money, and comparatively little was left for working capital. The features of the auriferous deposits were not at first grasped, and much money was wasted in mining in barren ground and amidst ancient workings, which were eventually found to reach to a depth of 300 feet. All the companies floated with such extravagant hopes in 1881-2 were moribund in 1885, and it was only a dying effort of the Mysore Company in that year that disclosed the great richness of the reef and incidentally the disposition of the auriferous chutes.

By 1887 the adjacent companies had resumed operations, and since then the history of the field has been one of uninterrupted progress and success. The deepest workings are now somewhat more than 3,000 feet below the surface, and the reef shows, at that depth, little diminution in the value or in the width of the quartz.

Neither mining nor milling offers any serious obstacles on this field. In the former the necessity for heavy timbering and filling to keep the roadways open is perhaps the most serious. The ore is not refractory, and yields its gold to a simple combination of amalgamation and cyaniding.

During the six years under review the annual tonnage crushed has been increased by 62 per cent., from 337,636 tons in 1898 to 546,752 tons in 1903. The gold yield has not shown a corresponding advance, rising only from £1,575,966 in 1898 to £2,284,000 in 1903, an increase of 44·3 per cent. The divergence between the increase of tonnage crushed and the increase of yield therefrom is due to the fact that, with the economies in mining and milling indicated by experience, it is now possible to profitably crush low-grade quartz that ten years ago must have been left in the vein.

For the six years under review the value of gold extracted was £11,310,038, or 60 per cent. of the total value (£18,687,818) extracted in the 21 years since the commencement of work under European supervision. With the increase in output dividends have also increased, rising from £739,114 in 1898 to £1,019,347 in 1903, or an increase of 38 per cent. The total dividends paid during the six years were £4,988,793, or 60 per cent. of the dividends (£8,287,071) paid since 1882, indicating that dividends and output have advanced *pari passu*.

The above dividends have been paid wholly by five companies situated on the line of the Champion reef—the Mysore, Champion Reef, Ooregum, Nundydroog, and Balaghat. A considerable amount of exploratory work has been done by other companies on the Kolar field and elsewhere in Mysore, but hitherto without profitable result.

Of the improvement schemes which will make greatly for the reduction of working expenses, and, to that extent, for the prolongation of the life of the Kolar field, the introduction of electric power from the Cauvery falls is probably the most important. This work was commenced about July 1902, and has since uninterruptedly supplied a little more than 4,000 horse-power to the various mining and metallurgical works. The power is transmitted from the Cauvery Falls over duplicate lines 91½ miles long. The cost to the companies for the first year was

£29 per horse-power, and for succeeding years the cost will be £18. The success of the scheme has led to its enlargement, and works in progress will enable the Mysore Government to materially increase the power available for consumption.

Table 26 shows the various statistics for the Kolar field for the period under review.

TABLE 26.—*Statistics o} Production in the Kolar Gold-field.*

YEAR.	Tonnage crushed.	Ounces, bar gold.	Value of gold extracted.	Dividends paid.	Royalty.
			£	£	£
1898 . .	337,636	412,966	1,575,966	739,114	78,009
1899 . .	339,526	446,397	1,678,464	762,600	83,154
1900 . .	401,687	509,272	1,879,085	767,586	93,619
1901 . .	450,272	530,142	1,923,081	874,158	95,219
1902 . .	499,664	533,492	1,969,442	825,928	97,365
1903 . .	546,752	597,884	2,284,000	1,019,347	(a)113,200
TOTAL . .	2,575,537	3,030,153	11,310,038	4,988,793	560,566

(*a*) Estimated.

Total value of gold produced from 1882 to 1903 inclusive ...	£ 18,687,818 11 3
„ „ of dividends paid „ „ „ „ ...	£ 8,287,071 7 2
Approximate value of Royalty paid to Mysore Government from 1882 to 1903 inclusive	£ 926,334 13 2

The work of the field is carried on by Europeans, Eurasians and Natives in the following proportions, calculated from the number employed during an average year (1902):—

	Per cent.
Europeans (including Italian miners)	2·05
Eurasians	1·58
Natives: men	89·83
Natives: women (employed only on the surface) . .	6·54

The following table indicates the risks attendant on mining in the Mysore State:—

TABLE 27.—*Showing Fatal Accidents in Mysore Mines for the years 1898 to 1903.*

YEAR.	No. of persons employed.	Death-rate per 1,000 employed.	Death-rate per 100,000 tons quartz crushed.	Death-rate per £100,000 worth of gold obtained.
1898 . .	21,597	2·45	15·70	3·36
1899 . .	21,093	1·80	11·19	2·26
1900 . .	24,587	2·61	15·68	3·35
1901 . .	25,060	2·99	16·65	3·90
1902 . .	26,268	2·21	11·58	2·90
1903 . .	27,355	2·52	11·27	3·02
Average .	*24,326*	*2·43*	*13·67*	*3·13*

Outside the Mysore State the only gold quartz mine producing gold at the end of 1903 was the Hutti (Nizam's) mine situated at Hutti in the Lingsugur district of Hyderabad. This company is an offshoot of the Hyderabad (Deccan) Company and was floated in 1901. Crushing with 10 head of stamps was commenced in February 1903, and 3,414 ounces were returned for that year. This result has been considered so promising that the crushing power is being doubled. The workings of this mine give evidence of the remarkable mining skill of the ancients, the auriferous chute having here been followed downwards to a depth of no less than 540 feet.

Nizam's Dominions.

Another offshoot of the Hyderabad (Deccan) Company was formed in 1898 to work the adjacent mines of Wundalli, and during 1899 crushed 18,790 tons of quartz for a yield of 7,822 ounces. The yield of the Nizam's territory during 1898-99-1900 was almost exclusively the produce of the Wundalli Company. Work was, however, stopped at these mines towards the middle of 1900.

The yield shown from the Madras Presidency was derived from the Mysore (Kangundi) mines in the Kangundi zemindari of North Arcot. Work commenced

Madras Presidency.

here in 1893, and was continued with varying success until 1900. The highest yield obtained was that for the year 1898, *viz.*, 2,854 ounces.

During the period under review the only other reef-mining of importance was carried on at the Kyaukpazat mine near Wuntho, in Upper Burma. This mine yielded, in 1898, 1,120 ounces, and maintained, and indeed increased its yield until 1902, when 1,984 ounces, valued at £7,606, were produced. This yield, however, formed merely another example of the general rule that auriferous deposits in andesitic rocks are extremely uncertain in extent and in richness. The pay chute was lost in 1903, and after some exploratory work the mine was closed down.

Burma.

Alluvial gold-washing is carried on in many places in British India, but from the fact that the washers invariably combine this pursuit with other occupations, and because the individual return is exceedingly small and is locally absorbed for jewellery, complete returns are not available. Returns for 1903 show, however, that 106 ounces of alluvial gold were obtained from the Ladhaki wazirat of the Jammu and Kashmir State. This amount may perhaps be fairly taken as an indication of the annual yield from this portion of the Upper Indus.

Dredging for alluvial gold above Myitkyina on the Upper Irawadi was commenced about November 1902, with a dredger capable of dealing with 10,000 tons a week. The whole of the season (until June 1903) was spent in prospecting the river bed. Five or six spots were thus tried, and the results were considered to be sufficiently satisfactory to warrant an increase of dredgers.

During the past two years surveys of the auriferous deposits of India have been in progress. These, so far as they go, give little hope of the discovery of rich alluvial deposits in Peninsular India, or indeed in any part of India affected by the monsoon rains and dependent on them alone for the supply of the rivers. For concentration of gold a comparatively equable current is essential—a condition rarely obtainable in the gravel river beds of India, where alone gold would be found, for these are almost dry in the cold weather and roaring torrents in the rains. The greater possibilities of dredging on the Irawadi appear to arise from the fact that the waters of that river are derived from ranges where, even in the cold weather, there is a heavy rainfall.

Graphite.

Mode of occurrence.

The graphite deposits of Travancore occur under conditions similar to those of Ceylon, which is but a continuation of the charnockite series and associated rocks of South India. Similar geological occurrences of graphite are found in Coorg, and in the hill tracts of Vizagapatam and adjoining State of Kalahandi. The Ceylon graphite has been made the subject of an elaborate study by E. Weinschenk, who regards it as of igneous origin,[1] a conclusion in agreement with its occurrences in South India.[2]

Production.

Prospecting for graphite has been attempted in the Godavari district, Madras Presidency, and in the Ruby Mines district in Upper Burma, but the only progress made in mining has been in the Travancore State. Regular returns were not available before 1901, but the following figures are returned for Travancore for the remaining three years of the period under review:—

1901	2,490 tons.
1902	4,575 „
1903	3,394 „

Iron.

Notwithstanding the fact, very widely published, that rich deposits of iron-ore occur in India, only one attempt to manufacture iron on European lines has been so far successful, and as it is doubtful if the ores are sufficiently valuable to bear the cost of transport to Europe, no attempt has been made to raise Indian iron-ore for export.

The production of ore is thus confined to that used by the Bengal Iron and Steel Company in its works at Barakar, and the smaller quantities, for which accurate returns are not obtainable, used in the numerous small native furnaces still surviving in parts of Central India, the Central Provinces, Madras, Mysore, and Rajputana. Iron-ore is also used in small quantities in the steel furnaces at the East Indian Railway Company's workshops, Jamalpur.

[1] Die Graphitlagerstätten der Insel Ceylon. Abhand., d. k. Bayer., Akad., 1901, xxi, 279—335.

[2] Holland: The Charnockite series, Mem. Geol. Surv. Ind., XXVIII, 1900, 126; and the Sivamalai series, Mem. Geol. Surv. Ind., XXX, 1901, 174.

The figures returned for Bengal, in which most of the ore used at Barakar is raised, are given in table 28.

TABLE 28.—*Iron-ore raised in Bengal during the years 1898 to 1903.*

YEAR.	Quantity.	Value.	Value per ton.
	Tons.	£	Shillings.
1898	41,854	7,006	3·35
1899	52,000	6,333	2·44
1900	57,000	7,333	2·57
1901	57,800	8,352	2·89
1902	76,056	11,287	2·96
1903	61,355	9,717	3·17
Average .	*57,678*	*8,338*	*2·89*

Up to the present the Barakar Iron and Steel Company has manufactured pig-iron only, of which with two blast furnaces they have turned out about 35,000 tons of pig-iron a year. But a third blast furnace is now in course of erection, and arrangements are complete for starting the manufacture of steel.

Outside Bengal there is very little done in the way of iron-manufacture. The Central Provinces show the largest returns, varying from 2,400 to 4,800 tons, and there is also a sensible industry surviving in Bijawar, Panna, and Orchha, amongst the Central India States, as well as in Mysore and in parts of the Madras Presidency.

Steel is made, both in the form of ingots by the carburization of wrought-iron in crucibles, and, on a much smaller scale, by the decarburization of cast-iron shot in a small open hearth.

Jadeite.

The mineral jadeite, like the jade with which it is often confused, is especially prized by the Chinese, and the quarrying of the mineral forms quite an important industry in Upper Burma. Some of the mineral raised passes by the overland route into South-West China, whilst most of it finds its way down to Rangoon, whence it is exported to the Straits Settlements and China. The following table shows the extent of this export trade:—

TABLE 29.—*Exports of Jadestone from Burma to the Straits Settlements and China.* (*a*)

YEAR.	Weight.	Value.	Value per cwt.
	Cwts.	£	£
1897-98	4,036	41,780	10·35
1898-99	4,532	42,120	9·29
1899-00	3,130	58,955	18·83
1900-01	4,531	46,377	10·24
1901-02	3,015	31,713	10·52
1902-03	4,220	47,676	11·06
Average .	*3,911*	*44,770*	*11·45*

(*a*) Overland trade and exports *viâ* Rangoon combined.

Value of jade.

Amongst prehistoric relics found in various parts of the World, both jade and jadeite implements and ornaments are widely distributed, and an admiration for the beauty of the stone, descended from a belief in its magical properties, maintains the value of the mineral in the eyes of the Chinese, who are the chief buyers, and to whom the different varieties of both minerals, and possibly some others, are known under the generic name *Yu-esh.* The softer, serpentinous mineral bowenite passes on the North-West Frontier under the name of *Sang-i-yeshm*, and though its characters are unmistakeably distinct from those of jade and jadeite, it is evidently regarded as a poor variety of jade.

Mode of occurrence.

Some jadeite, and often the best material, is obtained as pebbles in the gravels of the Uru river, a tributary of the Chindwin, but most of the material is obtained by quarrying near Tammaw (25° 44′; 96° 14′) in the Mogaung sub-division of the Myitkyina district, Upper Burma. At this locality the jadeite forms a layer in the dark-green serpentine, against which, on a fresh surface, it stands in striking contrast on account of its lighter colour. The serpentine is apparently intrusive into miocene sandstones, and the jadeite must have been separated as a primary segregation from the magma.

Composition.

There is a general external resemblance between jadeite and jade, or nephrite as it would be more appropriately called, but mineralogically the two are quite distinct. Jadeite is essentially a silicate of soda and alumina, Na_2O, Al_2O_3, $4SiO_2$, with the crystallographic characters of the pyroxene group. Jade is a silicate of lime and magnesia, CaO, $3MgO$, $4SiO_2$, with the essential characters of a hornblende. Their crystallographic characters sufficiently distinguish them in microscopic sections, but in hand-specimens jadeite can be distinguished by its superior hardness and higher specific gravity, as well as by its greater fusibility.

Jadeite occurs in masses of closely interwoven crystals, a structure which gives rise to its great toughness. The purest, though not the most valued, forms are white in colour, but more often there are various shades of green, and, in the case of stones found embedded in the laterite of Upper Burma, there is a red staining often extending to considerable depths in the pebbles, and, in the eyes of the Chinese purchaser, greatly increasing the value of the mineral. The white jadeite with emerald-green spots, caused by the presence of chromium, is also valued greatly for the carving of ring-stones or bracelets.

Prices.

The prices paid for rough stones vary too greatly to permit of an average figure being given, but the export values declared give an idea of the value of the stone: the value so determined has averaged £11·9*s*. per cwt. during the last six years.

No jade (nephrite) of the kind which would be regarded as a marketable mineral is known in India. A mineral having the essential composition, and approaching coarse jade in physical characters, is known in South Mirzapur.[1] True jade, however, has been largely worked in the Karakash valley in South Turkistan for many centuries.[2]

Magnesite.

In South India there are numerous occurrences of the ultra-basic igneous rocks in which olivine is an abundant constituent, and at

[1] F. R. Mallet, Rec. Geol. Surv. Ind., v, 22.
[2] *Cf.* papers quoted by Mallet in Manual, Geol. of Ind., part iv, 1887, p. 85.

several places these highly magnesian silicates have been decomposed with the formation of magnesite of great purity. The largest and best known of these occurrences is near Salem, where the area occupied by the white magnesite veins has been named the "Chalk" hills.

Prospecting operations have been in progress in this area for some years, but the industry may now be described as having passed into the mining stage, and on account of the remarkable purity of the mineral being raised it is expected to command a special price for the preparation of the refractory bricks used for the linings and hearths of steel furnaces, and for lining the fire-bricks of the electric calcium-carbide furnace. The production so far has been small—amounting to 3,540 tons in 1902 and 825 tons in 1903—but work is now being organized on a larger scale.

Manganese-ore.

Production.

The mining of manganese-ore has sprung-up within the last 12 years, and has developed so rapidly that India now takes second place amongst the manganese-producing countries in the World, with an output during the year 1903 of 171,806 statute tons. Table 30 shows the output for each of the past six years and figure 5 (page 13) shows the progress of the mining industry since its commencement.

TABLE 30.—*Production of Manganese-ore for the six years 1898 to 1903.*

YEAR.	Madras.	Central Provinces.	Central India.	TOTAL.	
	Statute Tons.	Statute Tons.	Statute Tons.	**Statute Tons.**	*Metric Tons.*
1898 . .	60,449	...	...	**60,449**	*61,419*
1899 . .	87,126	...	...	**87,126**	*88,524*
1900 . .	92,458	35,356	...	**127,814**	*129,865*
1901 . .	76,463	44,428	...	**120,891**	*122,831*
1902 . .	68,171	89,608	...	**157,779**	*160,311*
1903 . .	63,452	101,554	6,800	**171,806**	*174,563*

It will be seen from this table that the mining of manganese-ore was confined to the Madras Presidency until 1899, after which the rich deposits in the Central Provinces were attacked, and are now, notwithstanding their great distance from the coast, providing the chief part of the mineral exported to Europe and America.

Provincial division.

The statistics published by different countries cannot be directly compared, as different definitions of a manganese-ore are followed. According to the rulings of the United States Treasury before 1899, a manganese-ore was so-called only when it carried 50 per cent. of the metal; but in 1899 lower grades were admitted if they contained less than 3 per cent. of iron, and the recognised lower limit is now 44 per cent., those below this grade being generally manganiferous iron-ores. The statistics for 1902 show, in the case of the United States, a total production of 901,214 statute tons of manganiferous iron-ore, but only 16,477 tons came within the Treasury definition of a manganese-ore, whilst in the same period as much as 235,576 tons of the 50 per cent. ore was imported. Of the countries which supplied this amount, Brazil contributed 102,550 tons, India 64,170 tons, Cuba 36,294 tons, Turkey 12,609 tons, and Spain 10,464 tons.

Production of foreign countries.

Table 31 (on page 57) shows the chief producers of manganese-ore in the World. Of these Brazil has developed as rapidly as India, its output having risen from 14,710 tons in 1896 to 156,269 tons in 1902. Spain, the next producer, for many years turned out over 100,000 tons, but since 1900 has been declining rapidly. Russia has always been the leading producer, the chief source being beds of pure ore interstratified with eocene sands and shales in the province of Kutais.

The mineral is now assuming such importance that it will perhaps be useful for those who are following the developments to put on record a sketch of the distribution in India of deposits considered to be of possible value.

Distribution of manganese-ore in India.

In the Central Provinces, where mining is at present most active, the principal occurrences are in the Ramtek tahsil of the Nagpur district, where in some 17 different villages quarrying operations are being actively carried on. In the north-west part of the Bhandara district there are 14 localities known to contain manganese-ore, and a certain amount of work is in progress. In the Balaghat district 10 occurrences are known in the west of the district, whilst mining is being carried on near the town of Balaghat, and on another large deposit at Ukua in the Behir tahsil. In Chhindwara manganese-ore is known at 11 localities in the Sausar tahsil, whilst the mineral has long been known near Gośalpur and Sihora in the Jabalpur district. The ore has also been reported from the Khairagarh and Kalahandi States.

TABLE 31.—*Principal sources of Manganese-ore, and latest reported productions.*

COUNTRY.	Year.	Production.	COUNTRY.	Year.	Production.
		Tons.			Tons.
Russia	1900	884,200	Cuba (Exports) . .	1902	39,628
India	1903	171,806	Chili (Exports) . .	1901	31,477
Brazil (Exports) . .	1902	156,269	France . . .	1901	22,300
Spain . . .	1902	62,944	United States . .	1902	16,477
Turkey (Exports) .	1902	50,000	Japan . . .	1901	15,858
Germany . . .	1902	49,812	Greece . . .	1901	14,166

The deposits in the Central Provinces possibly belong to the same group of rocks which further to the south-east were first worked for manganese-ore in the Vizianagram State, and the intermediate jungle-covered country, which is very little known, will possibly yield further occurrences of the ore on more systematic exploration. In other parts of the Madras Presidency the ore has been reported in the Kallikota State, in the Ganjam district, and in the Sandur hills of Bellary.

One occurrence has been recorded in the Gwalior State, and one is now being worked in Jhabua, from which 6,800 tons were turned out in 1903, whilst there are several localities at which poor ores are found in the Dhár forest.

On the Bombay side, manganese-ores have been found at several places around Mahabaleshwar and Satara; in the southern part of Belgaum district; in Bijapur; near Jambughora in Rewa Kantha; and in the Dharwar district where prospecting operations are in progress. If the deposits in Dharwar and Belgaum approach those in the Central Provinces in quality, they will, on account of their proximity to the coast, develop very rapidly. Manganese has been reported also in the Tavoy and Mergui districts of South Burma, in the Nizam's Dominions, and in the form of manganiferous iron-ore near Chaibassa in Chota Nagpur.

Mode of occurrence, Nagpur area.

In the Nagpur area the manganese-ore occurs as lenticular masses and bands in the quartzites, schists, and gneisses, and as regards origin appears to have been formed at least partly, by the alteration of rocks composed of manganese-garnet, with which the mineral rhodonite, a manganese pyroxene, is often associated. Consequently the ore is frequently found to pass, both laterally and along the strike, into partly altered or quite fresh spessartite-quartz rock, or rhodonite-spessartite-quartz rock.

Dimensions of ore-bodies.

The ore-bodies often attain great dimensions, and their disposition as irregular lenses along the strike of the enclosing schists naturally influences the miner in laying out the boundaries of his "claims." A deposit near Balaghat is 1¾ miles long; at Manegaon in the Nagpur district the ore-body is 1½ miles long; whilst at Thirori in the Balaghat district it is nearly 6 miles in length. As examples of great breadth may be quoted Kándri, 100 feet thick, of pure ore, and Rámdongri, 1,500 feet of ore and unaltered spessartite (manganese-garnet) rock. The depth of these ore-bodies is quite unknown, as the so-called mining has so far passed little beyond the quarrying stage, and the question of possible exhaustion does not enter into the calculations of the present owners.

Composition.

This Nagpur ore is typically a mixture of braunite, and psilomelane, sometimes, though, entirely braunite—a hard, compact, pure ore, ranging well over 51 per cent. of manganese. The average material now being raised ranges between the following limits on analysis :—

	Per cent.
Manganese	51—54
Iron	5— 8
Silica	5— 9
Phosphorus	0·05—0·12
Moisture	usually below 1·0

The Vizianagram ore occurs under geological conditions apparently resembling those of Nagpur, though the enclosing rocks are sometimes too decomposed for precise petrological determination. There is another mode of occurrence in the Nagpur district, the ore occurring as nodules in crystalline limestone associated with piedmontite, and in places where there has been a dwindling of the limestone through water-action, these nodules of ore have accumulated in layers of a size which might be worth working. Occasionally in cavities in this limestone beautiful pyrolusite crystals are found.

Being near the coast, and consequently free of the tax of railway freight, it is possible to export a lower grade of ore from Vizianagram than from the Central Provinces. The ores shipped from Vizianagram show, according to Mr. H. G. Turner (*Journ. Iron and Steel Inst.*, 1896, I, 160) the following range of composition :—

Manganese	45—50 per cent.
Iron	7—13 „
Silica	2— 5 „
Phosphorus	0·12— 0·27 „
Moisture	1·10— 1·80 „

Jabalpur.

Manganese-ore occurs under different conditions in the Jabalpur district, where it is found in the Dharwar-like schist series which forms a belt with a maximum width of 7 miles stretching for 20 miles in a N.E.—S.W. direction. The rocks in this belt are various quartzites, phyllites, and schists, including hematite-schists and jaspers. The hematite-schists are slightly manganiferous and are often capped by a secondary deposit of limonite, in which psilomelane has formed into irregular nodules. Pyrolusite and psilomelane also occur in this district, sometimes occupying cavities in a siliceous breccia which is rather common.

Mahabaleshwar.

The manganese-ore occurring in the neighbourhood of Mahabaleshwar forms irregular nodules distributed through the laterite cover on the Deccan Trap, and the nodules are formed presumably by concentration of the residue from the action of meteoric waters on the basaltic rocks.

Valuation of manganese-ore.

For use in steel-making, manganese-ores should contain not more than 0·15 per cent. phosphorus nor more than 10 per cent. of silica. Under conditions laid down by the Carnegie Steel Company, ores containing less than 40 per cent. manganese and more than the above-mentioned quantities of phosphorus and silica may be rejected at the option of the buyer. Deductions from the scheduled price per unit are made also for every 1 per cent. of silica above 8 per cent. and for each 0·02 per cent. of phosphorus in excess of 0·1 per cent. Steel manufacturers pay an additional price per unit of iron present in the ore.

TABLE 32.—*Variation in the Price of Manganese-ore c. i. f. at United Kingdom Ports.*

Date.	50 per cent. Mn. and upwards.	47—50 per cent. Mn.	40—47 per cent. Mn.
	Pence per unit.	Pence per unit.	Pence per unit.
January 1898	9—12	8½—11	7½—10½
July 1898	9—12	8½—11	7½—10½
January 1899	10—12½	9—11	7½—10½
July 1899	12—14	10½—11½	8—10
January 1900	13—15	12—13	10—12
July 1900	13½—15	11½—12½	10—12
January 1901	12—14	11—12	10—11
July 1901	10½—11	9—10	—8
January 1902	9½—10½	9—9½	8—9
July 1902 . . .	9½—10½	9-9½	8—9
January 1903	10—10½	8½—9	7½—8½
July 1903	10—10½	8—9	7½—8½
January 1904	9—9½	8—9	6—8

Prices.

The prices paid for manganese-ore carrying over 50 per cent. of the metal, delivered at United Kingdom ports or at New York, ranged between 9 and 10 pence per unit at the end of 1903. Thus, an ore with 52 per cent. manganese would be valued at $\frac{52\times9}{12}=39$ shillings a ton. Table 32 (page 60) and the following diagram (figure 9) show the recent variations in the prices of ore of different grades :—

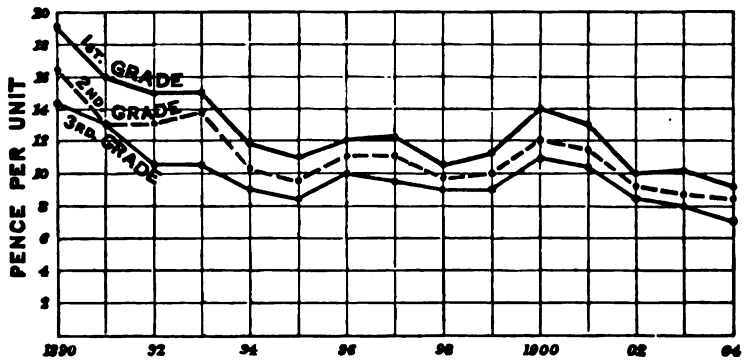


FIG. 9.—*Variation in the Prices of Manganese-ore at United Kingdom Ports since 1890.*

Economic considerations.

Owing to the distance of the chief deposits from the sea-board—amounting in the case of the Central Provinces to about 500-600 miles—and the heavy freight charges to Europe and America, only the high grades of ore can be touched. Ores which would be considered valuable within range of a steel-making centre are rejected in India, and the result is a regretful waste of the natural resources, which will continue until there is a demand in the country for ferro manganese and facilities for its manufacture. As the ore sent out of India ranges a little over 50 per cent. of manganese, the metal for which it is valued is charged with nearly double freight; but the present owners of mines have so far sunk comparatively little capital, and the so-called mines are mere open quarries worked by the assistance of no expensive plant; there is thus no present inducement for husbanding resources, and there will probably be no attempt, either to manufacture ferro-manganese from low-grade ores, or to make steel, before the inevitable decline in the mining industry takes place. There is now an apparent haste to make the most of the present circumstances, and as the Indian and Brazilian outputs have already affected the market, there is a very evident fear of depreciation in prices, and consequent curtailment of the life of the industry; for the export of manganese-ore will cease to be profitable long before the natural stocks of higher grades of ore are exhausted—when, in fact, quarrying passes into mining, and the simple excavation of rich ore now in sight in great quantities gives place to the more expensive process of selection. However, by all accounts and all appearances, there is yet a fair future before the present owners of manganese-ore quarries, and the wonder is, not that manganese-ore mining has developed so greatly in India, but that such rich deposits could have remained so long prominently exposed and yet untouched, as attention was directed to the best of them many years ago.[1]

One cannot help the feeling of regret that the whole industry is at present equivalent to a heavy loss to the country. The ore exported is worth perhaps Rs. 30 a ton in the country to which it is sent: this country gets out of it merely the margin left after paying the heavy freight charges, and possibly Rs. 15 a ton can be regarded as the profit to India, divided between the railways, the miners and the owners of the land. At the same time, India has to pay the foreign manufacturer's profits and the cost of return carriage for the manganese brought back in the form of steel. If a flourishing steel-manufacturing industry existed in the country, much of the manganese would be retained in India, and the lower-grade ores also would be economically developed. As it is, our manganese-ore is being exported to the three great steel-producing countries—England, United States, and Germany. The exports to Holland and Belgium shown in table 33 are in part for transmission to Germany, whilst the consignments sent to Egypt were booked to Port Said to await orders for delivery to ports further west.

Uses of manganese-ore.

It is only, however, within recent years that the demand for manganese in steel-making has grown so rapidly. Manganese-ore was formerly used in the chemical trade in various ways, but mainly for the production of the chlorine necessary to manufacture bleaching powder: it was then valued especially for its content in oxygen, in which respect the Indian braunite is inferior to pyrolusite. Now the conditions are reversed, and the ore being valued mainly on account of its manganese content, the sesquioxide, in braunite, which predominates in the Indian deposits, is more valuable than the dioxide, pyrolusite.

[1] V. Ball, Manual of the Economic Geology of India, 1881, 329.

TABLE 33.—*Distribution of exported Indian Manganese-ore for the years 1897-98 to 1902-03.*

COUNTRIES.	1897-98.	1898-99.	1899-00.	1900-01.	1901-02.	1902-03.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
United Kingdom	54,279	51,931	63,175	86,269	65,150	95,540
Belgium . .	...	...	5,350	13,300	...	1,000
France . .	...	...	...	5,850	...	...
Germany . .	...	...	...	...	11,300	10,734
Holland . .	...	..	8,350	16,500	...	5,050
Egypt . .	...	...	...	3,400	15,000	...
United States .	24,550	10,900	18,350	5,350	41,720	42,950
TOTAL .	78,829	62,831	95,225	130,669	133,170	155,274

Mica.

The returns of production for mica grossly understate both quantity and value, as both are below the export returns. As the only mica on which royalty is charged is that raised in Government land, and as many mica miners have mines in both Zemindari and Government land, there are obvious reasons for understating the production, and, besides this fact, the flourishing industry of stealing mica diminishes the returns for production without affecting the export figures.

Incomplete returns for production.

A considerable quantity of mica of the poorer grades is consumed in the country for ornamental and decorative purposes, and a small quantity of the larger sheets is used for painting pictures on in various parts of the country. As far as the figures for *quantity* are concerned, therefore, the exports cannot be accepted as an approximate expression of the production; but as regards *value,* the export returns may be accepted as a closer approach to the figures which should express production.

Exports.

From table 34 it will be seen that, during the years 1897-98 to 1902-03, the mica exported averaged 19,173 cwts., and had an average annual value of

Variations in value.

£77,613, or £4·05 per cwt. The variations in yearly value reflect a serious change in the trade which occurred in 1899. The diagram forming figure 6 (page 14) brings out this feature very strikingly. In 1898 Indian mica miners began to realize that their waste dumps contained a large supply of the material wanted for the manufacture of micanite, in which thin films of mica are cemented together and moulded into sheets, to serve many purposes for which the natural sheets only were used formerly. The waste heaps were consequently turned over, and the clear sheets of muscovite cleaned and split into thin films by gangs of children, who, by practice, could select the films of the required thickness with an accuracy which could scarcely be exceeded by the use of a micrometer. The large quantities of "flimsy" mica thus suddenly thrown on to the market raised the weight of mica exported, without a corresponding increase of value. Thus, figure 6 shows the curve for weight, suddenly rising in the years 1899—1901 until it crosses that for value, falling back with the reaction in the following year, but with a closer approximation of the two curves marking the years subsequent to 1901 when compared with those before 1898.

Export of films for micanite.

TABLE 34.—*Exports of Indian Mica during the years 1897-98 to 1902-03.*

YEAR.	Quantity.	Value.	Value per cwt.
	Cwts.	£	£
1897-98	11,608	71,234	6·14
1898-99	10,947	53,890	4·92
1899-00	22,599	73,372	3·25
1900-01	33,175	109,554	3·30
1901-02	16,298	70,034	4·30
1902-03	20,412	87,594	4·29
Average .	*19,173*	*77,613*	*4·05*

The same lesson is expressed in table 34, from which it will be seen that the average value of the mica sent out of the country in 1897-98 was £6·14 per cwt., and that this value dropped down to £3·25 in

1899-1900, when the cheaper mica was exported in quantity, with only a partial recovery in the following years, during which both the cheap kinds and the more expensive sheets were exported together.

Source of mica raised for export.

Table 35 shows the relative contributions of the mica exporting provinces, and in the case of Bengal and Madras the only provinces in which the industry can be regarded as established, the mica exported was that produced within the Presidency in each case. It will be seen from this table that, during the years under review, the two chief producers contributed to the average total as follows:—

Bengal . . .	12,282 cwts., valued at .	. £52,272
Madras . . .	6,872 „ „ .	. £25,241

The average value of the mica sent out of Bengal was thus £4·26 per cwt., whilst that from Madras was £3·67.

TABLE 35.—*Exports of Mica for the years 1897-98 to 1902-03.*

YEAR.	BENGAL.			BOMBAY.			BURMA.			MADRAS.		
	Weight.	Value.	Value per cwt.	Weight.	Value.	Value per cwt.	Weight.	Value.	Value per cwt.	Weight.	Value.	Value per cwt.
	Cwt.	£	£	Cwt.	£	£	Cwt.	£	£	Cwt.	£	£
1897-98	8,344	50,051	5·99	...	...	...	...	.	...	3,264	21,183	6·49
1898-99	7,720	31,954	4·14	11	50	4·55	10	258	25·8	3,206	21,628	6·75
1899-00 .	15,473	47,234	3·05	51	90	1·76	3	13	43·3	7,071	26,035	3·68
1900-01 .	13,633	63,049	4·62	25	100	4·00	...	...	...	19,517	46,405	2·38
1901-02 .	11,870	53,140	4·48	7	19	2·71	...	...	...	4,421	16,875	3·82
1902-03 .	16,651	68,202	4·10	6	72	12	...	...	...	3,755	19,320	5·15
Average	*12,282*	*52,272*	4·26	*20*	*66*	3·30	*3*	*54*	18·00	*6,872*	*25,241*	3·67

Distribution of mica exported.

Table 36 shows the average distribution of exported mica during the period under review. It will be noticed that the United Kingdom took the largest share, amounting to 73·2 per cent. of the average total value, but much of the mica sent to the United Kingdom is sold there for transmission to the Continent and America. The mica sent direct to America brought a higher price, as only the better qualities could face the heavy import duty imposed by the Dingley Tariff in 1897.

TABLE 36.—*Average Distribution of Indian Mica exported during the years 1897-98 to 1902-03.*

EXPORTED TO	AVERAGE QUANTITY.		AVERAGE VALUE.		Value per cwt.
	Cwts.	*Per cent. of total.*	£	*Per cent. of total.*	
United Kingdom .	14,843	*77·4*	56,799	*73·2*	3·83
United States . .	2,978	*15·5*	15,596	*20·1*	5·24
Germany . . .	1,027	*5·4*	3,920	*5·0*	3·82
Belgium . . .	141	*0·7*	634	*0·8*	4·50
France . . .	55	*0·3*	522	*0·7*	9·49
Hong Kong . .	90	*0·5*	26	...	0·29
Other Countries . .	39	*0·2*	116	*0·2*	2·97
Average Total .	**19,173**	*100·0*	**77,613**	*100·0*	4·05

Effects of the American tariff.

According to the Dingley Tariff, imported mica was divided into "unmanufactured" and "cut or trimmed," both being charged with a duty of 20 per cent. *ad valorem*, *plus* 6 cents a pound in the former case and 12 cents a pound in the case of "trimmed" mica. The duty had an immediate effect on the American mines by excluding all the lower grades of foreign mica, and thereby giving new life to many mines unable to face foreign competition without protection. For the five years preceding 1897 the average value of mica produced in the United States averaged £14,573 a year, whilst for the five years following 1897 the average annual value of the production was £25,518. The tariff was, however, insufficient to retard the growing demand for mica, and whilst the imports into the United States for the five years before 1897 had an average annual value of £33,481, those for the following five years averaged £61,880.

The tariff, however, naturally affected the Indian producer, who then contributed the chief part of the mica consumed in America, whilst the practice of preparing the mineral for the market became affected by the classification adopted, though some Indian producers were slow in observing the fact that mica sent to the London market in neatly trimmed rectangles was, on account of the higher duty, worth slightly less to the American buyer than the roughly dressed material.

Competition with Canada.

For many years India met with little competition from other countries in the American market, but during the last two years Canada has produced large quantities of phlogopite, and by meeting the requirements of the consumers of mica, has seriously challenged the supremacy of India. Table 37 shows approximately the relative positions of the three countries which, between them, produce well over 90 per cent. of the World's supply. India has so far enjoyed an easy lead, but there was a sudden expansion of the Canadian output in 1902, though reports recently received forecast a return to near the normal value of £32,000 for the year 1903.

TABLE 37.—*Value of Mica raised in the three principal producing countries.*

YEAR.	1898.	1899.	1900.	1901.	1902.	*Average.*
	£	£	£	£	£	£
India (*a*) . .	53,890	73,372	109,554	70,034	87,594	*78,888*
United States (*b*)	26,219	24,293	29,592	23,715	23,769	*25,518*
Canada . .	24,324	33,493	34,110	32,877	(*c*)82,192	*41,399*

(*a*) Exports only. | (*b*) Value at the place of production.
(*c*) Preliminary figures subject to revision.

Mining methods.

The methods of mining and the distribution of mines do not differ materially from those described in a special Memoir issued two years ago.[1] The short-sighted

[1] T. H. Holland: The Mica Deposits of India. Mem. Geol. Surv. Ind., vol. XXXIV, part 2, 1902.

policy then described is beginning now to impress itself on the mica-miners, who will be fortunate if no other country steps in to secure the market which could be controlled by India, or no artificial substance is found to meet the growing demand for mica, before the miners learn the necessity for reorganizing their methods.

Prospecting rules.

The rules for the grant of prospecting licenses and mining leases for mica in Bengal were revised in April 1902, and are printed *in extenso* with those for Madras in the Memoir on Indian Mica published by the Geological Survey in 1902. The important changes introduced in the rules were:—

(1) The levy of a royalty in the case of prospecting licenses at the rate of 5 per cent. on the sale value of mica;
(2) The abolition of the system of putting up leases of mica mines to auction, and provision for restricting operators to approved methods;
(3) The raising of the maximum period of leases to 30 years;
(4) The grant of power to lessees to relinquish their grants during the currency of their leases.

Prospecting licenses granted.

Of the prospecting licenses issued during the period under report, seven were granted in Nellore, four in Coimbatore, one in Godavari, and one in the Tinnevelly district, Madras Presidency. In the Central Provinces, one was granted in each of the three districts, Balaghat, Hoshangabad, and Chhindwara. In Burma, one license was issued for each of the two districts of Magwe and Mandalay, and two each for Myitkyina and the Ruby Mines district. In Assam, one license was granted in the Khasia and Jaintia hills. In Rajputana, four licenses were granted in Ajmer-Merwara, making a total of 27 licenses, covering 3,223 square miles.

Labour statistics.

Most of the mica mines having come under the control of the Indian Mines Act of 1901, labour statistics for the last three years of the period under review are now available. These are summarised in table 38, from which it will be seen that the mica industry comes next to gold in providing labour, whilst the risks attending mica-mining, as now practised, are rather greater than those of coal mining in India, though the period is too short for a fair comparison of the two industries.

TABLE 38.—*Labour Statistics of Mica Mines for the years 1901 to 1903.*

	Province.	1901.	1902.	1903.	*Average for 3 years.*
Number of persons employed.	Bengal .	6,254	7,363	6,464	*6,694*
	Madras .	2,965	21,137	2,312	*2,471*
	TOTAL .	**9,219**	**28,500**	**8,776**	**9,165**
Number of Deaths from Accidents at Mica Mines.	Bengal .	2	2	9	*4·33*
	Madras .	16	...	...	*5·33*
	TOTAL .	**18**	**2**	**9**	**9·66**
Death-rate per 1,000 persons employed at Mica Mines.	Bengal .	0·32	0·27	1·39	*0·65*
	Madras .	5·39	...	...	*2·16*
	Average .	*1·95*	*0·21*	*1·02*	*1·05*

Petroleum.

Total production. More progress has been made, during the period under review, in developing the petroleum resources than those of any other mineral.* The output in 1897 amounted to 19 million gallons, and at the time was a record production, but the outturn has since been quadrupled, and in 1903 amounted, as shown in table 39, to nearly 88 million gallons.

Position of India amongst oil-producing countries. But still India contributes little more than 1¼ per cent. of the World's supply of mineral oil.[1] Figures for all other countries are not yet obtainable for 1903, but table 40 (page 71) shows the position India occupied amongst oil-producing countries in 1901 and 1902, when its output exceeded 50 million gallons. With the United States and Russia overwhelming all others by producing over 90 per cent. of the World's supply, India takes a place amongst the second group of producers, and at the present rate of expansion will soon be competing with the Dutch East Indies, where the oil-fields are situated on a geological extension of the Assam-Burma belt.

[1] Preliminary returns for 1903 show that the Indian output was 1·29 per cent. of the World's total supply. (*Petroleum Review*, Oct. 22, 1904, p. 330.)

TABLE 39.—*Production of Petroleum during the years 1898 to 1903.*

YEAR.	QUANTITY.		Value.
	Gallons.	Metric tons. (a)	
			£
1898	22,234,438	89,295	76,821
1899	32,934,007	132,265	125,684
1900	37,729,211	151,523	148,755
1901	50,075,117	201,105	204,342
1902	56,607,688	227,340	217,816
1903	87,859,069	352,848	354,365

(a) The metric ton is assumed to be equivalent to 249 gallons of crude petroleum having a specific gravity of 0·885.

Imports.

India is, however, still far from meeting all its own requirements in mineral oil. The imports during the past six years have averaged nearly 85½ million gallons, valued at £2,314,891 (table 41, page 72), but the fall after the maximum of 1901-02 was continued into 1903-04, and it now appears, consequently, that foreign supplies are actually being displaced. It is interesting to notice that, of the two great producers, Russia and the United States, which have been supplying between them 93·5 per cent. of the imported foreign oil, Russia has been gradually increasing its predominance over the United States in the Indian market. In 1897-98 Russia contributed 58·1 per cent. of the imports and the United States 29·7 per cent., but in 1901-02 the former had secured 85·5 and the latter only 9·5 per cent. of the Indian custom, though a slight reversal occurred in 1902-03 (see table 41).

Value of imports.

As shown in table 42 (page 73), the predominance of Russia as a supplier of mineral oil to India is more a matter of quantity than of value, for although both countries supply large quantities of the cheaper kinds of oil, the supplies of more expensive kerosenes come from America, and the average price per gallon of the American oil is greater than that from Russia, prices on the whole having been enhanced in the former case from an average of 6·66 pence per gallon in 1897-98 to 7·81 pence per gallon in 1902-03, and having been depressed in the case of Russian oil from an average of 6·47 pence per gallon in 1897-98 to 5·93 pence in 1902-03.

TABLE 40.—*World's Production of Petroleum in 1901 and 1902.*

COUNTRIES.	1901.		1902.	
	Gallons.	*Per cent. of Total.*	Gallons.	*Per cent. of Total.*
United States . .	2,428,621,790	*41·84*	3,106,842,060	*47·94*
Russia . . .	2,980,899,460	*51·38*	2,818,901,575	*43·50*
Sumatra, Java and Borneo.	106,354,500	*1·84*	205,100,000	*3·17*
Galicia . . .	113,804,040	*1·96*	144,975,600	*2·24*
Roumania. .	49,215,600	*0·85*	72,097,550	*1·11*
India . . .	50,075,117	*0·86*	56,607,688	*0·87*
Japan . . .	38,500,000	*0·67*	41,755,000	*0·64*
Canada . . .	20,037,500	*0·35*	18,200,000	*0·28*
Germany. . .	10,977,050	*0·19*	12,378,625	*0·20*
Peru . . .	2,529,135	*0·04*	2,100,000	*0·03*
Italy . . .	353,500	*0·02* (Italy and Other Countries)	420,000	*0·02* (Italy and Other Countries)
Other Countries .	700,000		910,000	
TOTAL .	5,802,067,692	*100·00*	6,480,288,098	*100·00*

Occurrences of Indian petroleum.

The petroleum resources of India are confined to the two systems of folded rocks at either end of the Himalayan arc—

(1) The Iranian system on the west, including the Punjab and Baluchistan, and continued beyond British limits to Persia, where the oil-fields have attracted interest for many years.

(2) The Arakan system on the east, including Assam and Burma, with their southern geotectonic extension to the highly productive oil-fields of Sumatra, Java, and Borneo.

TABLE 41.—*Origin of Foreign Mineral Oil imported into India during the years 1897-98 to 1902-03.*

COUNTRIES.	1897-98.		1898-99.		1899-00.		1900-01.		1901-02.		1902-03.		*Average.*	
	Gallons.	*Per cent. of Total.*	Gallons.	*Per cent. of Total.*	Gallons.	*Per cent. of Total.*	Gallons.	*Per cent. of Total.*	Gallons.	*Per cent. of Total.*	Gallons.	*Per cent. of Total.*	*Gallons.*	*Per cent. of Total.*
Russia . .	50,672,226	58·1	50,940,879	62·2	57,658,254	76·9	67,350,856	83·4	84,514,016	85·5	71,197,917	80·1	63,722,358	74·6
United States .	25,967,322	29·7	23,602,079	28·8	15,043,622	20·1	9,798,257	12·1	9,437,107	9·5	13,425,470	15·1	16,212,310	18·9
Other Countries.	10,685,478	12·2	7,408,514	9·0	2,257,557	3·0	3,639,469	4·5	4,935,082	5·0	4,249,857	4·8	5,529,326	6·5
TOTAL .	**87,325,026**	100·0	**81,951,472**	100·0	**74,959,433**	100·0	**80,788,582**	100·0	**98,886,205**	100·0	**88,873,244**	100·0	85,463,994	100·0
Value .	£ 2,433,976		£ 2,163,152		£ 2,120,086		£ 2,304,562		£ 2,557,882		£ 2,309,151		£ 2,314,801	

TABLE 42.—*Average Annual Value of Mineral Oil imported during the years 1897-98 to 1902-03.*

COUNTRIES.	Average annual value.	Average value per gallon.
	£	Pence.
Russia	1,666,571	6·28
United States . . .	483,220	7·22
Other Countries . . .	165,011	7·17
Average Annual Total and Average Price.	**2,314,802**	**6·50**

In both areas the oil is associated with Tertiary strata, and has had probably similar conditions of origin in both cases, but the structural features of these areas are not equally suitable for the retention of oil in natural reservoirs. In Burma, however, the conditions have been locally ideal: the well-known Yenangyaung field lies in a N. N. W.—S. S.E. flat anticline, the axis of which by variation in pitch has produced a flat dome in the Kodaung tract. The rocks in this dome include a porous sand at depths of 200—300 feet, covered by impervious clay-beds, which have helped to retain the oil until the impervious layers are pierced by artificial wells. In the Baluchistan area the rock-folds have been 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 they are mere "shows," not connected with reservoirs which can be tapped by artificial means.

Punjab.

In the Punjab, oil-springs have been known for many years to exist in the Rawalpindi district and further to the south-west, but the total output of the Punjab is small, ranging between 1,000 and 2,000 gallons a year. During the past six years the recorded production has been as follows:—

1898	1,510 gallons.
1899	1,104 "
1900	1,874 "
1901	1,812 "
1902	1,949 "
1903	1,793 "

Unsuccessful attempts have been made to develop the oil resources indicated by springs in different parts of Baluchistan; the most prominent of these are near Khatan in the Mari hills and Moghal Kot in the Sherani country, where small oil springs which were examined in 1891 were found to yield oil of a very high quality. The oil-spring in the neighbourhood of Moghal Kot affords a good illustration of the way in which a country, originally well endowed with the necessary conditions for the natural production of petroleum, may lose its resources by subsequent destruction of the natural reservoirs. The Moghal Kot oil-bearing beds form a very open anticlinal fold, whose axis pitches to the E.N.E., and if the dome possessed the necessary plastic, impervious envelope, the oil rising up from below would have become concentrated in the porous beds which form the saddle, but for the fact that along this line the rocks are more easily eroded by surface water, and the anticline thus forms the gorge of a river by which the rocks have been opened to permit the waste of oil for an indefinite time. This is, unfortunately, the history of most of Baluchistan and the Punjab, where the oil-bearing strata are either disturbed beyond the plastic limit of the impervious layers, or the whole series of beds (those which are porous and hold the oil, as well as those which are impervious and limit its movements underground) have been exposed to the air. In this respect the Punjab-Baluchistan area offers fewer prospects of success than the eastern group of Assam and Burma, where, especially in the latter area, the rocks are less disturbed and the softer shales have retained their nearly impervious character.

Baluchistan.

Up to the present, however, all attempts to develop the oil prospects of India have been without success, except in Burma and North-East Assam. Burma holds an easy lead, and if its resources hold out, the present rate of development will soon displace foreign supplies.

The delay in the development of the promising petroleum resources of Assam is an instance of a remarkable diffidence and want of enterprise existing in a commercial community which could show the reckless speculation of the gold boom of 1890. As long ago as 1865 an account of the Makum area was published by Mr. H. B. Medlicott, F.R.S., in the Memoirs of the Geological Survey, and trial borings were then recommended. This advice was followed in 1867, when a Calcutta firm obtained permission to prospect, and struck a promising oil-spring at a depth of 118

Assam.

feet near Makum; but nothing more was done until 1883, and only very slow development occurred in the following sixteen years. The Assam Oil Company was, however, formed in April 1899 with a nominal capital of £310,000, most of which was quickly called up and invested in the erection of a new refinery at Digboi and in systematic drilling operations, with the result that the output rose from 631,571 gallons in 1901 to 2,528,785 gallons in 1903. Besides the ordinary illuminating oil and solid paraffins, the Assam Oil Company has made a successful attempt to put petrol on the Indian market. The following table shows how the output in this area has been rising during the last six years:—

1898	547,965	gallons.
1899	623,372	,,
1900	753,049	,,
1901	631,571	,,
1902	1,756,759	,,
1903	2,528,785	,,

The belt of Tertiary rocks extending from the north-eastern corner of Assam for some 180 miles south and west shows frequent signs of oil, nearly always in association with coal and sometimes associated with brine-springs and gas-jets. The series of earth-folds in which this corner of Assam occurs stretches southwards to Cachar, where oil springs are also known, through the little-known Lushai hills into Arakan, and in the same system of parallel folds occur the oil-fields of the Arakan coast on one side of the Yoma and those of the Irawadi valley on the other (see plate 6).

Burma.

The most productive oil-fields of Burma are those on the eastern side of the Arakan Yoma, in the Irawadi valley, forming a belt stretching from the Magwe district, in which the well-known field of Yenangyaung occurs, through Myingyan, in which Singu occurs, across the Irawadi into Pakokku, where Yenangyat is situated. Oil is, however, known further south in Minbu, Thayetmyo and Prome, and further north in the Chindwin valley, but these areas have not so far been thoroughly prospected, and the great development which has recently taken place has been the direct outcome of work in the three fields, Yenangyaung, Yenangyat, and Singu.

Yenangyaung.

Yenangyaung, the best known and most developed of the fields, still holds the lead as a producer. The oil in this area has been worked by native wells on both sides of the dome for well over 100 years, and before 1886 the annual yield was generally over two million gallons, but soon after systematic drilling was introduced in the central Kodaung tract in 1887 the output gradually rose to over 10 million gallons in 1894, and last year, 1903, reached a record of 56,920,662 gallons.

TABLE 43.—*Production of the Burma Oil-fields between 1898 and 1903.*

YEAR.	Yenang-yaung, Magwe District.	Singu, Myingyan District.	Yenangyat, Pakokku District.	Akyab.	Kyauk-phyu.	TOTALS.	
	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	Gallons.	*Metric tons.*
1898 . .	15,484,301	...	6,036,088	58,025	105,549	**21,684,963**	*187,088*
1899 . .	22,111,514	...	10,030,790	50,559	116,668	**32,309,531**	*129,757*
1900 . .	27,123,325	...	9,701,769	36,852	112,342	**36,974,288**	*148,491*
1901 . .	37,482,935	...	11,843,341	22,355	93,103	**49,441,734**	*198,561*
1902 . .	40,712,142	174,880	13,824,390	36,794	100,774	**54,848,980**	*220,277*
1903 . .	56,920,662	5,617,381	22,665,518	52,968	71,962	**85,328,491**	*342,685*
Average .	*33,305,813*	*2,896,130* (*a*)	*12,350,316*	*42,926*	*100,233*	**46,764,665**	*187,810*

(*a*) Two years only.

Yenangyat yielded very small supplies of petroleum before 1891, when drilling was started by the Burma Oil Company. The expansion was slow until 1894, when 324,086 gallons were produced, but rose rapidly to 6,036,088 gallons in 1898 and to 22,665,518 gallons in 1903. The oil from the Yenangyat area, and that from its southward extension on the other side of the Irawadi river near Singu, contains a higher proportion of the lighter hydrocarbons than the Yenangyaung crude oil.

Yenangyat.

Singu has suddenly come into prominence. Petroleum was first struck by the Burma Oil Company in this area on the 30th October 1901, and arrangements were then made to provide tanks for its reception. Production did not consequently begin till 1902, when only 174,880 gallons were turned

Singu.

out with the opening of the new wells, but the output jumped up to 5,617,381 gallons in 1903. The crude oil first obtained had a specific gravity of 0·8247 and flash point under 40° F., in consequence of which primary stills were erected on the field to remove the light naphthas before transport to the Rangoon refineries.

Arakan coast.

Besides the Upper Burma oil-fields, the islands off the Arakan coast, noted for their mud volcanoes, have also been known for many years to contain oil deposits of uncertain value. The chief operations have been carried on in the Eastern Barongo Island near Akyab and on Ramri Island in the Kyaukphyu district. During the past six years the average output of the former area has been 42,926 gallons, whilst in Kyaukphyu the output in the same period has averaged about 100,000 gallons, with a distinct tendency to decline.

Bulk system of transport.

The main factor which has contributed elsewhere to the recent great advances in oil production, namely, the general adoption of the bulk system of transport and distribution, has been receiving the attention of those interested in the development of the Burma oil-fields. The Burma Oil Company have laid a pipe-line from Yenangyat, through Singu, to the Yenangyaung area, and are now preparing to connect all the fields in a similar way with their refineries in Rangoon, a distance of 275 miles; they are adding several large tank steamers to their present fleet of five, with storage tanks at the principal Indian ports. The enterprise shown in the laying out of capital in Burma evidently anticipates an expansion in the trade well beyond the record output of 1903, and the fact that mineral oil is being rapidly adopted as fuel instead of coal, removes the fear of over-production which seemed likely as long as petroleum was used only as an illuminant.

Ruby.

During the period under review the ruby-mining industry in Upper Burma underwent a new and favourable phase, the mineral having become, next to petroleum, the most profitable source of revenue amongst Burmese minerals. Various leases were granted in the ruby-bearing area near Nanyaseik in the Myitkyina district, and in the "stone-tract" of the Sagyin hills, in Mandalay district, and the results have been mostly profitless; but the returns for the Mogok area, where the Burma

Ruby Mines Company is paramount, show that the industry has entered a most encouraging phase. The Company was granted the right in 1889 to mine for rubies and to levy royalties from persons working by native methods, the lease being renewed in 1896 for 14 years, at a rent of Rs. 3,15,000 a year *plus* a share of the profits. The results being, however, unsatisfactory from the shareholders' point of view, the rent was reduced in 1898 to Rs. 2,00,000, the share of the profits being, at the same time, raised from 20 to 30 per cent. A dividend of 5 per cent. was paid for the first time in 1898, when the value of the rubies obtained amounted to £57,950. In 1899 the Company obtained rubies to the value of £90,848 and paid a dividend of 12½ per cent. : in this year three unusually valuable stones were found, one of 77 carats being valued at 4 lakhs of rupees (£26,666). In the following year, 1900, the value of the stones raised increased to £97,326, and the Company paid a dividend of 17½ per cent. The year 1901 showed the record output of stones valued at £104,476, whilst in 1902 they brought £86,895. In the last year, 1903, the Company's receipts were £98,575, and profits on the year's working £44,950.

Salt.

Origin of Indian salt.

There are three kinds of sources from which salt is produced in India :—

(1) Sea-water, from which 61·8 per cent. of the total production was obtained during the period under review ;

(2) Sub-soil water and lakes in areas of internal drainage, in both of which the origin and mode of concentration of the salt are the results of essentially similar natural processes. From these sources about 27 per cent. of the total was obtained ; and

(3) Rock-salt beds, from which 11·2 per cent. of the total was obtained by mining and quarrying.

Production.

During the past six years, 1898 to 1903, the average annual production of salt in India amounted to 979,572 statute tons. Table 44 shows the variations for the past six years and plate 4 shows graphically the position India has taken amongst the large salt-producing countries during the past 22 years.

TABLE 44.—*Production of Salt in India (excluding Aden).*

YEAR.	Statute Tons.	*Metric Tons.*
1898	986,158	*1,001,982*
1899	920,659	*935,432*
1900	1,005,185	*1,021,315*
1901	1,102,039	*1,119,672*
1902	1,040,206	*1,056,899*
1903	823,184	*836,394*
Average	*979,572*	*995,282*

TABLE 45.—*Provincial Production of Salt during the years 1898 to 1903.*

	1898.	1899.	1900.	1901.	1902.	1903.	*Averages.*
	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	Statute Tons.	*Statute Tons.*
Aden	41,217	41,181	49,763	87,800	58,953	71,656	*54,428*
Bengal	...	...	174	112	44	94	(*a*) *106*
Bombay . .	343,569	368,072	460,262	323,909	381,611	267,619	*357,507*
Burma	18,223	23,240	20,835	21,500	20,013	26,174	*21,664*
Gwalior State .	456	333	352	491	485	489	*434*
Madras . . .	251,875	268,962	322,244	339,544	358,450	244,923	*297,666*
Northern India .	359,790	248,574	190,532	405,068	269,177	270,068	*290,535*
Sind . . .	12,245	11,478	10,786	11,415	10,426	13,817	*11,695*
TOTAL Statute Tons.	**1,027,375**	**961,840**	**1,054,948**	**1,189,839**	**1,099,159**	**894,840**	**1,038,000**
Metric Tons . .	*1,043,862*	*977,269*	*1,071,877*	*1,208,933*	*1,116,797*	*900,200*	*1,054,665*

(*a*) Average of 4 years.

Provincial contributions to the total production.

Of the provinces contributing to this amount, Bombay, with an average annual production of 357,507 tons, and Madras, with an average of 297,666 tons, between them contributed almost exactly two-thirds of the total. Of the salt produced in Bombay, about 78 per cent. was obtained from sea-water, the rest being manufactured from sub-soil brine at Kharaghora and Udu on the border of the lesser Rann of Cutch, and possibly derived from infiltrated sea-water. The Madras salt is practically all made from sea water, a very small quantity of spontaneous salt being collected at Pandraka in the Masulipatam sub-division.

The chief manufacture of salt in Burma takes place also along the sea-coast, but sub-soil brine is evaporated at various places in Upper Burma, notably in the Lower Chindwin, Sagaing, Shwebo, Myingyan, and Yamethin districts, and in smaller quantities in Minbu and Meiktila, as well as at Mawhkeo in the Hsipaw State. During the past six years the average annual production of this salt in Burma has been 3,432 tons.

In Sind 88 per cent. of the salt raised during the years 1898 to 1903 was obtained from sea-water, and 12 per cent. from the Saran and Dilyar deposits on the edge of the great desert.

From the point of view of the geologist and mineralogist, the last two groups of occurrences, namely, sub-soil salt and rock-salt, are naturally of more interest than the first, though from the financial point of view the salt from sea-water, being the predominating fraction, is the most important source of revenue.

Sub-soil and internal lake brine.

The second form of occurrence is characteristic of areas in which evaporation of rain-water is excessive compared to run-off, and the salt recovered in these areas is that merely arrested on its journey to the sea, where, in the same way, it is concentrated by evaporation of the water. The most prominent of such areas is the desert-belt of Rajputana including the salt-lakes of Sambhar, Didwana, Falodi, Lonkara-sur and Kachor-Rewassa, with a brine-impregnated sub-soil along the whole valley of the Luni, as well as the country to the west in Sind, around the Rann of Cutch and the delta of the Indus. To the north of the Rajputana country sub-soil brine is raised and evaporated for salt in a cluster of villages in the Sultanpur mahal, south-west of Delhi. Other places occur in parts of the United Provinces and in Berar, where large quantities of salt were formerly obtained from sub-soil brine in the alluvium of the Purna River. In Gwalior State salt is regularly manufactured from sub-soil brine, the average annual production during the years 1898 to 1903 having been 434 tons. In Behar a small quantity of salt is separated in the manufacture of saltpetre. The returns for the past four years for Bengal, with an average of 106 tons per annum, quoted in table 45, refer to salt made in this way.

Sambhar Lake.

The most important source of salt of this group is the Sambhar Lake in Rajputana. Recent investigations have shown that Sambhar is a silt-filled depression in the Aravalli schists and gneisses, in which a body of mud and sand, with kankar and gypsum (some 75 feet thick in what appears to be about the centre of the depression) includes from 2 to 12 per cent. of sodic chloride, with smaller quantities of sodic sulphate, sodic carbonate, and potassic sulphate. Every year the water brought in by the rivers, which are in flood during the monsoon, forms a lake some 60 square miles in area and 2 to 3 feet deep. The water, which is fresh when it first comes in, takes up salt from the accumulated stocks in the silt and forms a strong brine, which is partly led into prepared enclosures (*kyars*) for the separation of salt by solar evaporation, partly isolated by temporary reservoirs constructed to cut off bodies of the lake-water in anticipation of the recession towards the centre during evaporation, and partly forms a thin crust of white glistening salt on the bed of the lake, where it is allowed to remain until the arrival of the next monsoon and the usual annual flooding of the lake.

Production and prospects of Sambhar.

During the past six years the average annual removal of salt from the Sambhar brine has been 135,051 tons, which is 13·8 per cent. of the average annual production for India during the same period. Since the lake came under the direct control of Government in 1871 the salt removed has amounted to about 4 million tons. During the past few years the quality of Sambhar salt is said to have depreciated, and it has been suspected that the large quantities which have been removed have at last made an impression on the great stores of salt which must have accumulated in the lake silt, appreciably raising the proportion of the associated compounds, sodium sulphate, sodium carbonate, and potassium sulphate. An investigation is now being made with a view to forming an estimate of the total and relative amounts of these salts present in the lake mud, and of obtaining a forecast of the effects of fractional solution and crystallization under the existing system of manufacture.

Distribution of Sambhar salt.

The chief fraction of the output of Sambhar is consumed in the United Provinces, but small quantities reach as far even as Behar against the competition of foreign salt imported through Calcutta. The following table shows the average annual distribution of Sambhar salt during the years 1897-98 to 1902-03:—

United Provinces . . .	91,443 tons, or	68·3 per cent. of total.
Rajputana	20,371 " "	15·3 " "
Central India	11,713 " "	8·8 " "
Punjab and North-West Frontier Province	9,109 " "	6·8 " "
Central Provinces . . .	716 " "	0·5 " "
Behar	175 " "	0·1 " "
Sind (in 1902-03 only) . . .	294 " "	0·2 " "

Distribution of Didwana and Pachbadra salt.

The salt being manufactured at Didwana is practically all consumed in Rajputana and the adjoining districts of the Punjab. During the years 1897-98 to 1902-03 the average annual amount, 10,502 tons, disposed of from this source was divided into 8,123 tons for the Punjab and 2,379 tons for Rajputana. Pachbadra salt, of which only small lots entered the Punjab, had an average distribution as follows during the period under review:—

Average Distribution of Pachbadra Salt during the years 1897-98 to 1902 03.

United Provinces . .	15,346 tons, or	45·6 per cent. of average total
Rajputana . . .	9,216 " "	27·3 " " "
Central India . . .	5,553 " "	16·5 " " "
Central Provinces . .	3,562 " "	10·6 " " "
TOTAL .	33,677 tons.	

Production of rock-salt.

The production of rock-salt in the Punjab, North-West Frontier Province and Mandi State is shown in table 46, from which it will be seen that, of the average annual output of 109,540 tons, 89,023 tons, or 81·2 per cent., came from the Salt Range mines, whilst 14·5 and 4·3 per cent. respectively came from Kohat and Mandi,

TABLE 46.—*Production of Rock-Salt during the years 1898 to 1903.*

YEAR.	Salt Range, Punjab.	Kohat North-West Frontier.	Mandi State.	TOTAL.	Percentage of total salt production of India.
	Tons.	Tons.	Tons.	Tons.	
1898	91,117	17,223	4,754	113,094	11·4
1899	91,488	17,693	4,621	113,802	12·3
1900	81,534	14,900	4,122	100,556	10·0
1901	91,816	14,965	4,845	111,626	10·1
1902 . . .	87,426	14,674	5,152	107,252	10·3
1903	90,736	15,598	4,554	110,888	13·5
Average . . .	*89,023*	*15,842*	*4,675*	109,540	*11·2*
Per cent. of Average Total .	81·2	14·5	4·3	100·0	

The Salt Range deposits.

The chief deposits of rock-salt are in the so-called Salt Range of the Punjab, where the seams of salt and included marl partings have, where worked in the Mayo mines at Khewra, an aggregate thickness of 550 feet, of which five seams of pure salt make up 275 feet, the rest, known as *kalar*, being too earthy and impure to be marketable. These beds occur in a formation lying directly underneath beds of Lower Cambrian age, but it is suspected that they may be of Lower Tertiary age, like the other salt deposits of this part of India, and that they have arrived in their present apparently anomalous position by an overthrust of the older fossiliferous beds.

Mining for rock-salt is carried on in the Mayo mines, Jhelum district, the Warcha mines in the Shahpur district, and across the Indus at Kalabagh. The rock-salt in this area varies from white to brick-red in colour and thus differs in colour from that of the Kohat area.

The Mayo mines.

The most important of the mines in the Salt Range are the Mayo mines near Khewra (32° 39′; 73° 3′). In this area salt-quarrying was practised for an unknown period before the time of Akbar, and was continued in a primitive fashion until it came under the control of the British Government with the occupation of the Punjab in 1849. In 1872 the system of mining was reorganized, and the work now in operation was planned out by Dr. H. Warth, late Deputy Superintendent, Geological Survey of India.[1]

The rock-salt being raised in the Mayo mines has, on account of its purity, a wide distribution. A recent analysis of one of the seams gave the following results:—

Sodium chloride	98·86
Sodium sulphate	0·57
Sodium carbonate	trace
Magnesium chloride	nil
Moisture	0·08
	99·51

The Warcha mine.

In the Warcha mine, Shahpur district, the seam of rock-salt being worked is 20 feet thick, with a one-foot parting of marl, dipping 30° to the N. N. W.

Kalabagh quarries.

About two miles E.N.E. of Kalabagh on the Indus, rock-salt is worked in open quarries on the east slope of Sandagar hill.

Distribution of Salt Range salt.

The rock-salt raised in the *cis*-Indus mines and Kalabagh quarries is principally consumed in the Punjab and North-West Frontier Province. During the past six years the average annual sales in these provinces amounted to 70,964 tons, or 82·3 per cent. of the total. In the same period the rock-salt sent to the United Provinces averaged 10,049 tons a year, or 11·3 per cent., whilst as much as 5·7 per cent. of the total sales, or an annual average of 4,933 tons, reached as far as Behar, and small consignments of about 10 tons a year were despatched to Lower Bengal. The average annual amount of 580 tons which entered Sind formed 0·7 per cent. of the sales for the years 1897-98 to 1902-03.

Kohat quarries.

The Kohat salt is grey in colour with transparent patches. It is worked in open quarries, and the masses exposed may be regarded as practically inexhaustible at the present rate of output. In the anticlinal at Bahadur Khel, where the salt is seen to be at the base of Tertiary system, the beds can be

[1] For detailed description, see "Report on the Inspection of the Mayo Salt Mine," by J. Grundy, 1898, pp. 13-15.

traced for a distance of about eight miles, with an exposed thickness of over 1,000 feet.

Mandi quarries.

In Mandi State, rock-salt is worked in open quarries near the faulted junction of the Tertiary and the older unfossiliferous rocks at Guma and Drang. The Mandi salt is of a dirty plum-colour, containing earthy impurities which bring down the available sodic chloride to 60 or 70 per cent.

Imports and origin of Foreign salt.

With low freight-rates from Europe, large quantities of salt are imported, especially into Bengal and Burma, against the competition of the domestic produce. The salt imported during the six years under review averaged 433,754 tons per annum, of which 56·1 per cent., as shown by table 47, came from the United Kingdom, the remaining supplies being obtained, in order of average quantity, from Germany, Aden, Arabia, Egypt, and Persia. The average annual value of the salt imported during the six years was £456,263.

TABLE 47.—*Origin of the Salt imported during the years 1897-98 to 1902-03.*

Imported from	Average annual quantity imported.	Per cent. of total.
	Tons.	
United Kingdom	243,216	56·1
Germany	56,928	13·1
Aden	49,350	11·4
Arabia	42,887	9·9
Egypt	28,377	6·5
Persia	12,441	2·9
Other Countries	555	0·1
Average Total for the years 1897-98—1902-03	433,754	100·0

The amounts taken by the different provinces maintained a fairly constant ratio throughout the period, with the following yearly averages:—

Imported to Bengal	. . . . .	389,376 tons.
„ „ Burma	. . . . .	43,978 „
„ „ Bombay	. . . . .	260 „
„ „ Madras	. . . . .	91 „
„ „ Sind	. . . . .	49 „
	TOTAL .	433,754 „

Of the average annual amount imported, therefore, 89·8 per cent. entered India through Bengal. The distribution of foreign salt in India in competition with the chief sources of production is reviewed in the annual reports of the various Salt Departments.

Trans-Frontier Imports and Exports.

Small quantities of salt are also imported across the land frontier, coming in with borax mainly from Tibet. During the years 1898 to 1903 these imports averaged 1,476 tons annually, of which 1,416 tons came from Tibet. At the same time considerable quantities of Indian salt were sent across the frontier. The average annual export in this way during the six years under review amounted to 41,170 tons. The principal fractions went to Nepal (12,943 tons) and into Kashmir (11,234 tons).

Saltpetre.

Conditions essential for the formation of saltpetre.

For the formation of saltpetre in a soil the necessary conditions are (1) supplies of nitrogenous organic matter, (2) climatic conditions favourable to the growth and action of Winogradsky's so-called nitroso and nitro bacteria, converting urea and ammonia successively into nitrous and nitric acids, (3) the presence of potash, and (4) meteorological conditions suitable for the efflorescence of the potassium nitrate at the surface. An ideal combination of these necessary circumstances has made the Behar section of the Gangetic plain famous for its production of saltpetre.

In this part of India we have a population of over 500 per square mile, mainly agricultural in occupation, and thus accompanied by a high proportion of domestic animals, supplying an abundance of organic nitrogen. With a mean temperature of 78° F., confined to an annual range of 68°, and for a large part of the year, when the air has a humidity of over 80 per cent., with a diurnal range not exceeding 8° above or below 84° F., the conditions are unusually favourable for the growth of the so-called "nitrifying" bacteria.

With a population largely using wood and cow-dung for fuel, the soil around villages naturally would be well stocked with potash; and finally, with a period of continuous surface desiccation following a small rainfall, the sub-soil water, brought to the surface by capillary action in the soil, leaves an efflorescence of salts, in which, not surprisingly, potassium nitrate is conspicuous. Under these conditions Behar has for many years yielded some 20,000 tons of saltpetre a year.

System of manufacture.

The system of manufacture has been very frequently described in detail,[1] and consists essentially in dissolving out the mixed salts contained in soil around villages, and effecting a first rough separation of the two most prominent salts—sodium chloride and potassium nitrate—by fractional crystallization. The impure sodium chloride is consumed locally, whilst the saltpetre is sent to refineries for further purification before export.

Production and export.

The returns for production are so manifestly imperfect, being considerably below the amounts of export, that the export figures must be taken as the only index, though still an imperfect one, to the extent of the manufacture. The export figures for the past six years are given in table 48, showing an average annual export of 382,353 cwts., valued at £262,592.

Variations in exports.

There is no definite directional change indicated by these figures, but a comparison with the returns for the past 20 years shows that there has been only a slight reduction in the amount of exported saltpetre, in spite of the discovery elsewhere of large deposits of sodic nitrate, now being largely consumed in America, of variations in tariff, and of wholesale changes in the substances used for manures and for the manufacture of explosives. For the six years 1878—1883 the average quantity of saltpetre exported amounted to 405,568 cwts. a year, whilst for a similar period ten years later, namely, 1888 to 1893, the average annual exports were 389,989 cwts. The highest values, ranging from about £600,000 to nearly £900,000 a year, occurred at the time of the American Civil War from 1860 to 1864, but saltpetre was then an essential constituent of explosives and India had almost a monopoly of supplies.

[1] G. Watt, Dictionary of the Economic Products of India, vol. VI, part II, s. 686, p. 433, and literature quoted.

TABLE 48.—*Total Exports of Saltpetre during the years 1897-98 to 1902-03.*(a)

YEAR.	QUANTITY.		Value.	Value per cwt.
	Cwts.	*Metric tons.*		
			£	Shillings.
1897-98	417,788	*21,224*	265,831	12·73
1898-99	365,256	*18,555*	232,896	12·75
1899-00	397,402	*20,189*	256,210	15·16
1900-01	348,636	*17,711*	294,249	16·88
1901-02	354,412	*18,005*	237,880	13·42
1902-03	410,626	*20,861*	288,487	14·05
Average .	*382,353*	*19,424*	*262,592*	*13·73*

(a) Includes exports across the frontier which averaged 380 cwts., due mainly to 2,233 cwts. sent into Kashmir in 1900. The saltpetre sent across the frontier seldom exceeds a ton per annum.

Distribution of exported saltpetre.

There have been various changes amongst the consumers of small quantities, amounting altogether to about 20 per cent. of the total, but the quantities sent annually to the three larger markets, United Kingdom, United States, and Hong Kong, amounting to 80 per cent. of the total, have remained fairly constant.

Provincial shares in the exports.

Calcutta is still, as it always has been, the chief port through which saltpetre leaves India, the exports through Calcutta, during the period under review, having amounted to 98·5 per cent. of the total. Of the remaining small amount exported, 1·2 per cent. left *viâ* Karachi. The average annual exports from the different provinces have been as follows during the years 1897-98 to 1902-03:—

Bengal	376,254	cwts.
Bombay	930	"
Madras	61	"
Sind	4,728	"
TOTAL .	381,973	"

The Calcutta supply is obtained mainly from Behar, as shown in table 50, which has been compiled from returns published each year by the Commissioner of Northern India Salt Revenue.

TABLE 49.—*Average Distribution of Saltpetre exported by Sea during the years 1897-98 to 1902-03.*

EXPORTED TO	Average annual quantity.	*Per cent. of average total.*
	Cwts.	
United Kingdom	117,126	30·7
Hong Kong	98,320	25·7
United States	91,790	24·0
Mauritius	24,070	6·3
France	22,752	6·0
Straits Settlements	10,012	2·6
Ceylon	7,569	2·0
Japan	5,227	1·4
Other Countries	5,107	1·3
Average Total for the years 1897-98—1902-03	**381,973**	100·0

TABLE 50.—*Average Annual Imports of Saltpetre into Calcutta for the years 1897-98 to 1902-03.*

OBTAINED FROM	Average annual quantity.	*Per cent. of average total.*
	Cwts.	
Behar	230,120	59·1
United Provinces	113,680	29·2
Punjab	44,300	11·3
Rajputana and Central India	1,540	·4
Lower Bengal	100	...
Average Total	**389,740**	

Trans-Frontier imports.

Only very small quantities of saltpetre for chemical and medicinal purposes are imported into India by sea, but a considerable quantity comes from Nepal. During the past six years the imports from Nepal have averaged 9,417 cwts. with considerable yearly variations, as shown below :—

Saltpetre imported from Nepal.

1897-98	9,308 cwts.
1898-99	12,836 "
1899-00	15,655 "
1900-01	4,590 "
1901-02	11,352 "
1902-03	2,758 "
Annual Average .	*9,417* "

As the total annual imports of saltpetre averaged only 9,430 cwts. during the six years under review, the contribution from Nepal was the only one of importance. The annual values returned for the total imports give an average of £5,816, or of 12·34 shillings per cwt.

Tin.

Unworked occurrences.

Tin has a wider distribution than is generally recognised, and its minerals are often overlooked through the difficulty in distinguishing them from other heavy minerals. Isolated crystals of cassiterite have been found recently in pegmatites associated with gadolinite in the Palanpur State,[1] whilst in the Hazaribagh district of Chota Nagpur instances have been recorded of the accidental production of tin from river sands by the native iron smelters, in addition to the recorded occurrences of ores *in situ*. The principal deposit, which has either been wrongly described or has received less attention than it deserves, occurs in the Palganj estate near the Barakar river.

Worked deposits.

The only persistent attempts made to work tin have been in Burma, where cassiterite is obtained by washing river gravels in the Bawlake State, Karenni, Southern Shan States, and in the Tavoy and Mergui districts of South Burma. The work done on these deposits hitherto has been, however, on a

[1] Rec. Geol. Surv. Ind., xxxi, 1904, 43.

smaller scale than might be expected from the favourable reports which have been made as to their extent and richness. Table 51 shows the amounts of tin-ore raised during the years under review in Tavoy and Mergui, but the returns are probably approximate only, and no returns are available for Upper Burma. The average for the period has been 1,645 cwts. (82·5 tons) valued at £6,876.

TABLE 51.—*Production of Tin-ore in South Burma.*

YEAR.	Tavoy.	Mergui.	TOTAL.	
			Quantity.	Value.
	Cwts	Cwts.	Cwts.	£
1898	...	780	**780**	2,553
1899	14	1,408	**1,422**	7,900
1900	19	2,059	**2,078**	8,534
1901	22½	1,372	**1,395**	7,773
1902	25	1,970	**1,995**	5,340
1903	34	2,164	**2,198**	9,153
Average	*19*	*1,626*	*1,645*	*6,876*

Exports of block tin.

The metal is exported mainly in the form of block tin, almost all of it going to the Straits Settlements. This, during the years 1897-98 to 1902-03, averaged 661 cwts. a year, as shown in table 52.

Imports of block tin.

The tin exported from Burma is a small quantity compared to the requirements of the country. Table 53 shows the amounts of foreign unwrought block tin which have been consumed in India during the period under review, and in addition to these quantities, smaller quantities of tin-plates are imported. By far the largest quantity of block tin imported into India comes from the Straits Settlements. Out of the average total of 26,867 cwts., the quantity coming from the Straits averaged 25,407 cwts. per annum. A curious feature connected with the imports is the fact that the quantities of foreign tin imported have not increased since statistics of weight were first recorded in 1875-76. In that year the tin imported was reported to amount to 36,159 cwts., of which 31,479 cwts. came from the Straits.

TABLE 52.—*Exports of Burmese Block Tin for the years 1897-98 to 1902-03.*

YEAR.	Quantity.	Value.
	Cwts.	£
1897-98	905	2,816
1898-99	810	2,898
1899-00	757	4,613
1900-01	534	3,08
1901-02	455	2,574
1902-03	502	2,881
Average	*661*	*3,144*

TABLE 53.—*Consumption of Foreign Block Tin in India.*

YEAR.	IMPORTS.		Re-exports.	Consumption.
	Quantity.	Value.		
	Cwts.	£	Cwts.	Cwts.
1897-98	38,483	146,554	1,609	36,874
1898-99	29,099	110,667	1,396	27,703
1899-00	17,292	91,525	2,473	14,819
1900-01	22,591	146,135	2,624	19,967
1901-02	25,907	156,212	1,853	24,054
1902-03	27,830	169,731	1,495	26,335
Average	*26,867*	*136,804*	*1,908*	*24,959*

As regards the prospects of tin-mining in Burma, it may be worth notice that the country in which the ore occurs lies in a belt connecting Yunnan, the south-west province of China, in which tin-mining is said to support a large population,[1] and the well known tin-ore deposits of the Straits Settlements to the south, from which, in 1903, 54 per cent. of the World's supply of tin was obtained.

Prospects of tin-mining.

At the same time, it should be kept in mind that the tin-ore of the Straits has been obtained entirely from alluvial deposits, and that the ore found in lodes has always turned out to be too poor to work. The rapid rate of rock denudation in the wet zone of the tropics is responsible for the fact that rich alluvial deposits may accompany poor lodes, and consequently the occurrence of tin-ore in the sands and gravels of Burma does not warrant the hope that workable lodes will be found before the placer deposits are exhausted. That rich placer deposits exist of sufficient magnitude in Burma also does not necessarily follow from the fact that there is a continuity in the solid geology; the existence of a placer deposit is but a temporary accident in the geological history of a country, and each one must be gauged for itself.

[1] A. Leclère. Exploration géologique des Provinces chinoises voisines du Tonkin. *C. R., 29eme Session, Assoc. Fr.*, 1900, ii, 916-926. Abs. *Trans. Inst. Mining Engineers*, XXII, 1901-02, 715.

IV.–MINERALS OF GROUP II.

Alum and Aluminium-ore.

THE separation of the sulphate of alumina from decomposed pyritous shales, and the preparation of the double sulphate of alumina and potash, by the introduction of nitre or wood-ashes, was formerly an important industry in a few places, and, on a smaller scale, was practised at numerous places in India. But the importation of cheap alum, principally from the United Kingdom, and its wide distribution by the gradually extending network of railways, have now nearly killed the native industry. Table 54 shows that during the past six years the consumption of foreign alum in India has averaged 66,086 cwts.

TABLE 54.—*Consumption of Foreign Alum in India.*

YEAR.	IMPORTS.		Re-exports.	Consumption of foreign alum.
	Quantity.	Value.		
	Cwts.	£	Cwts.	Cwts.
1897-98	103,307	30,928	3,050	100,257
1898-99	70,999	18,837	3,320	67,679
1899-00	65,953	17,404	4,037	61,916
1900-01 . . .	64,528	18,398	3,137	61,391
1901-02	49,914	15,137	2,240	47,674
1902-03	61,081	18,789	3,478	57,603
Average .	*69,296*	*19,915*	*3,210*	**66,086**

No returns are available to show the amount of production in India. Near Kalabagh, on the Indus, considerable quantities of a pyritous shale are extracted for this purpose, but the mining is carried on in an irregular, fitful way, and the returns are probably mere rough estimates. In 1898 the output was reported to amount to 750 tons, valued at £3,150, but no returns are available for 1899 and 1903. In 1901 and 1902 the production was reported to be 98 and 112½ tons respectively.

Bauxite.

India possesses a possible asset of great value in the deposits of laterite which cover considerable areas in the Peninsula and Burma. On account of their commonly rusty colour, and on account of the fact that locally the native smelters, content with a poor ore, have employed laterite as a source of iron, the only chemical work done on laterite was formerly devoted to a determination of its content in iron. It has only recently been ascertained that many of the deposits contain large quantities of alumina, and are in all essential respects identical with the substance known as bauxite, which is now the chief source of aluminium. It is a curious coincidence that for a long time the original bauxite of Les Baux was, like laterite, first worked without success as a source of iron.

It is difficult at present to fully estimate the value of this discovery, as a deposit of laterite, which would ordinarily be regarded as small and of little consequence, contains enough alumina in some of the instances examined to completely swamp the market of bauxite, of which the World's total production is at present little more than 110,000 tons a year. Without any disturbance of present prices, the aluminous laterites would hardly pay, at the ordinary rate for first class bauxites of 21 to 22 shillings a ton, to mine for export to Europe and America, and they must consequently be utilized for the extraction of alumina on the spot, either for export as such, or for the manufacture of aluminium in the country. To prepare the alumina from the bauxite (or laterite) would, according to the most recent processes, require the use of caustic soda, which is not at present made in the country. But one of the latest successful processes for the manufacture of caustic soda involves the separation of chlorine (from which bleaching powder is prepared) by the electrolytic decomposition of dilute brine, and as both caustic soda and bleaching powder are now largely imported for use in paper-making, there would be a market for both, apart from the requirements of alumina manufacture.

Amber.

The returns for amber show the irregularities which might be expected of an industry conducted in a casual fashion by the half-civilized inhabitants of an unadministered area. The following table (table 55) shows the estimated production for the six years under review :—

TABLE 55.—*Production of Amber in the Myitkyina District, Upper Burma.*

YEAR.	Quantity.	Value.
	Cwts.	£
1898	114	1,061
1899	20	151
1900	9	103
1901	97	(a) 11
1902	30	432
1903	37	414
Average	*51*	*362*

(a) Poor qualities only raised for medicine in 1901.

Occurrence.

The Burmese diggings for amber are situated in the Hukong valley in the Nangotaimaw hills near Lalaung village at about lat. 26° 10′ and long. 96°. The substance is found in clays of probably miocene age, and fragments of amber have been similarly found in association with beds of this age in other parts of Burma, for example, at Mantha in the Shwebo district, and on the oil-field of Yenangyat in the Pakokku district. Most of the material is brought from the Hukong valley in Upper Burma to Mandalay, where beads for rosaries, *nadaungs* (ear-cylinders) and other trinkets for personal ornament are made from the transparent varieties.

Chemical and physical properties.

The amber of Burma differs in chemical and physical characters from previously known varieties, and the name burmite has been consequently suggested for it as a specific distinction.[1] The well known amber of Eastern Prussia contains from 2½ to 6 per cent. of succinic acid, and

[1] O. Helm, *Records, Geol. Surv. Ind.*, xxv, 180 (1892), and xxvi, 61 (1893).

is consequently known to the mineralogist as succinite, but the Burmese amber contains no succinic acid, though the products of its dry distillation include formic acid and pyrogallol. Its ultimate chemical composition has been determined to be as follows:—

Carbon	80·05
Hydrogen	11·50
Oxygen	8·43
Sulphur	0·02
	100·00

The specific gravity of burmite varies between 1·030 and 1·095. It is distinguished from many other amber-like resins by its superior hardness and greater toughness, which render it fit for carving and turning. It possesses a peculiar fluorescence, like that which distinguishes the Sicilian variety simetite.

Apart from the occurrence of a large percentage of discoloured and opaque pieces, many of the large fragments obtained are damaged by cracks filled in with calcite; but otherwise there appears to be a large quantity of material which might be put on the market with profit. At present it is said to be unable to withstand the competition of imported Prussian amber, even in the Mandalay bazar, and the market has to a certain extent been depressed by cheaper foreign material and by an artificial substance re-made from amber chips.

Antimony.

Prospecting operations for antimony-ores, amongst which stibnite is the most prominent, have been carried on in South Burma, and in Lahoul, where a large deposit occurs near the Shigri glacier. The latter occurrence is included in a mining lease recently granted, and an attempt is about to be made to mine the ore.

Much of the material sold in the bazars under the name *surma* includes galena as well as antimony, and the word has the same wide significance which the term " black lead " once possessed.

Arsenic.

Details with regard to the production and use of Indian arsenic are not available, but there has been a considerable trade in both Indian and foreign arsenic, presumably in the form of the white oxide.

Table 56 shows the extent of this trade for the period under review, but does not include the trade in orpiment, which is shown separately.

TABLE 56.—*Average Annual Exports and Imports of Arsenic for the years 1897-98 to 1902-03.*

—	Quantity.	Value.
	Cwts.	
Exports of Indian Arsenic—		
To Straits Settlements	308	
" Other Countries	26	
TOTAL .	334	£ 525
Imports of Foreign Arsenic—		
From the United Kingdom	421	
" " Germany	829	
" " China	909	
" " Straits Settlements	99	
" " Other Countries	88	
TOTAL .	2,346	£ 3,110
Re-export of Foreign Arsenic	111	

Orpiment.

Orpiment, the yellow sulphide of arsenic, is largely imported into Burma from Western China for use mainly as a pigment. During the six years 1897-98 to 1902-03, the average annual imports across this frontier amounted to 9,551 cwts., at an estimated value of £11,470, or 24 shillings per cwt. The last three years have shown a decided increase in the trade, with, however, an average reduction in the price per cwt. (see table 57).

TABLE 57.—*Imports of Orpiment from Western China.*

YEAR.	Quantity.	Value.	Value per cwt.
	Cwts.	£	Shillings.
1897-98	3,165	4,534	28·65
1898-99	5,253	7,523	28·64
1899-00	8,712	11,582	26·59
1900-01	12,075	14,822	24·55
1901-02	17,268	21,195	24·55
1902-03	10,831	9,163	16·92
Average	*9,551*	*11,470*	*24·02*

The mineral is used as a pigment in the manufacture of Indian ornamental lac-wares and the Burmese lacquer-work, in which the favourite greens of the Pagan workers are produced by mixtures of indigo and orpiment, and the so-called gold-lacquer of Prome by powdered orpiment and gum. It is used also for the designs on the Afridi wax-cloths.[1]

Asbestos.

Asbestos has not yet passed beyond the prospecting stage in India, although attempts have been made, during the past three or four years, to work the occurrences in Merwara, Rajputana, Garhwal in the United Provinces, and Hassan in Mysore.

Borax.

No undoubted occurrence of borax is known within British Indian territory, and the material exported, which, during the last six years, has averaged annually 4,481 cwts., of a value of £6,370 (table 58), is practically all obtained from Tibet, being imported across the frontier into the Punjab and United Provinces. The word *tincal,* by which it is known in the bazars, is possibly a corruption of the Tibetan name for borax, and is in common use on the Punjab frontier, where one meets,

[1] G. Watt, Indian Art at Delhi, 1903, pp. 211, 221, 222, 231.

in the Himalayan passes, herds of goats and sheep coming down in the spring from Tibet, each carrying two small bags of borax or salt to be bartered for Indian and foreign stores.

TABLE 58.—*Exports of Borax by Sea from India during the years 1897-98 to 1902-03.*

YEAR.	QUANTITY.		Value.	Value per cwt.
	Cwts.	*Metric tons.*		
			£	Shillings.
1897-98	3,624	*184*	4,339	23·95
1898-99	4,999	*254*	6,429	25·72
1899-00	4,405	*224*	6,304	28·62
1900-01	3,190	*162*	5,020	31·47
1901-02	5,666	*288*	8,594	30·34
1902-03	5,002	*224*	7,534	30·12
Average .	*4,481*	*228*	*6,370*	*28·43*

In addition to the borax sent by sea to foreign countries, small quantities cross the frontier into Nepal, Kashmir, and Kalat. During the six years, 1897-98 to 1902-03, these trans-frontier exports of borax have averaged 23 cwts. a year, with an average total value of Rs. 377 (£25) or R.s 16·4 (22*s.*) per cwt. The export trade has very seriously declined. Twenty years ago the borax sent out of India amounted to over 16,000 cwts. a year, valued at £24,000. At that time the principal part of the material exported went to the United Kingdom (14,134 cwts. in 1883-84), but with the discovery of large deposits of calcium borate in America the demand for borax from India ceased, and now the only large customers are in the Straits Settlements and China, the latter having taken 3,827 cwts., and the former 468 cwts., of the average annual total of 4,481 cwts. exported.

The amount of borax imported into India across the frontier has averaged (as shown in table 59) 21,955 cwts., of the value of £17,369; adding to this the small quantity of refined material imported by sea, namely, an average of 214 cwts., it is seen that the consumption in India has averaged 17,655 cwts. per annum during the years 1897-98 to 1902-03.

TABLE 59.—*Imports of Borax by Land during the years 1897-98 to 1902-03.*

YEAR.	Quantity.	Value.	Value per cwt.
	Cwts.	£	Shillings.
1897-98	15,273	12,097	15·84
1898-99	16,564	13,053	15·76
1899-00	20,315	16,424	16·17
1900-01	18,621	15,065	16·18
1901-02	31,085	24,096	15·50
1902-03	29,874	23,482	15·72
Average	*21,955*	*17,369*	*15·82*

Of the amounts brought across the frontier, and shown in table 59 to have an annual average of 21,955 cwts., 1,117 cwts., or 5·1 per cent., came from Ladakh, whilst 20,831 cwts., or 94·9 per cent., came from Chinese Tibet.

The borax obtained in the Puga valley of Ladakh, Kashmir, is deposited from hot springs, associated with sulphur deposits, which probably represent the final phase of declining volcanic action. The material collected in Tibet is obtained from salt lakes, which have possibly obtained their borax in a similar way from hypogene sources. In other parts of the World, as in California, Argentina, Bolivia, and Chile, deposits of calcium borate, colemanite, are worked for their boracic acid, besides the borax of salt lakes and marsh deposits. In Italy borax is obtained from volcanic fumaroles.

Building-Stone.

If the extent of the use of building materials could be expressed by any recognised standard, it would form one of the best guides to the industrial development of a country. The attempt made to obtain returns of building-stone, road-metal and clays used in India was abandoned when it was shown in 1899 that the returns could not possibly rank in value much above mere guesses. The same remark might possibly apply to any other country, where figures are regularly reported, though they are of little value for comparative purposes on account of the varying systems of making estimates.

In the United Kingdom, where land is generally sufficiently valueable to cause an increase of depth in quarrying to be less expensive than horizontal extension, a large proportion of the quarries come under the control of the Mines Acts, and regular returns for production are consequently available; but in India there are only a few quarries of more than 20 feet in depth, and the returns from them represent an unimportant fraction of the total amount of material which is being raised all over the country for public works of all kinds. For the present, therefore, we must be content with a general statement to represent the changes from one period to another.

In the absence of statistics, it is difficult to express shortly the trade in material so widespread as common building-stone. There are, however, a few features which are specially developed in, if not peculiar to, India. In the southern part of the Peninsula, various igneous rocks—the charnockite series near Madras, and the gneissose granites of North Arcot and Mysore—are largely used; in the centre, slates and limestones from the Cuddapah series, and basalt from the Deccan trap-flows are largely used. In Central India, Central and United Provinces, the great Vindhyan system provides incomparable sandstones and limestones, whilst in Bengal the Gondwana sandstones are used on, and within easy distance of, the coal-fields.

The abundant development of concretionary carbonate of lime in the great alluvial plains, and the extensive development of laterite on the Peninsula and in Burma are dependent, in their more pronounced forms, on conditions peculiar to tropical climates, and these two substances, the so-called kankar and laterite, are about the most valuable assets in building material possessed by the country.

The three great physical divisions of India, being the result of three distinct geological histories, show general contrasts in the materials available for simple as well as ornamental architecture. In the great alluvial plains, buildings of importance are naturally most often made of brick, but the margins on all sides admit of a certain inward diffusion of stone, which has been extended by increased facilities for transport. In this respect it is interesting to see that at last the monotony of brick buildings in Calcutta is being relieved by the introduction of the Vindhyan sandstones of Mirzapur, and the calcareous freestones and buff traps brought from the west coast. But the use of Italian marble, mainly for floorings, and, in a smaller way, the introduction of polished granite columns and blocks from Aberdeen and Peterhead, have been persisted in mainly because these materials, which are no better than, and possibly on the whole inferior to, those of Indian origin, are placed on the market in a manner suitable to the immediate requirements of the builder and architect. It is thus not because of the dearth of natural resources, but it is on account of the want of enterprise, that Indian ornamental building stone is less used in the chief cities.

During the six years under review the stone and marble imported from foreign countries into India had an average annual value of £19,848, and of this amount the value of marble from Italy was £10,221, or 51·5 per cent. of the average annual total. It is naturally surprising to find that a country which owes its reputation for architectural monuments as much to the fact that it possesses an unlimited supply of ornamental building stone as to the genius of its people, is dependent on foreign supplies to the extent indicated by these import returns. It can hardly be an accident that each dynasty, which has existed in India since the wonderful Buddhist topes of Sanchi and Bhahrut were erected, has been marked by the erection of great monuments in stone, and there can be little doubt that the abundance of suitable material has been an important contributory cause in the growth of India's reputation for architecture.

A recent development of importance has occurred in quarrying the nummulitic limestones of the Khasia and Jaintia hills, partly for use in the manufacture of lime or for use as simple limestone, and partly for the manufacture of cement near Calcutta. In 1898 the amount of limestone quarried in this district was estimated at 61,105 tons, but considerable fluctuations were shown in subsequent years with a general improvement to 88,675 tons in 1903.

For some of the quarries in Lower Vindhyan limestone near Katni, which have come under the control of the Indian Mines Act, returns are available since 1901, when the quantity raised was 28,000 tons, followed by 30,091 tons in 1902, and 35,238 tons in 1903. A limestone of Upper Vindhyan age is being worked near Sutna by a joint stock company, but much of the material is carried by rail a distance of 530 miles to the Barakar Iron Works, where it is used as a flux in the blast furnaces.

Chromite.

Chromite is known to occur with the peridotites of the Chalk hills near Salem, in the Andamans, and in Baluchistan. Attempts were made long ago to work the deposits near Salem, but nothing has been done since. In Baluchistan the ore occurring in the Pishin and Zhob districts is being opened up for export, the output for the first year of work, 1903, being returned as 284 tons. Larger quantities are now being raised, the amount for the first half of 1904 being 1,816 tons.

Clays.

No statistics approaching any degree of completeness are obtainable to show the extent of the undoubtedly great industrial value of the clays in India. They include the common clays used all over the country for the manufacture of bricks, tiles and the cheaper forms of pottery; finer varieties used for glazed pottery, which in places has obtained a reputation for artistic merit; fire-clays raised in considerable quantities on some of the Gondwana coal-fields; and fuller's earth, which is mined in the Central Provinces and in Rajputana.

The imports of materials coming under this head show that there is room for the development of the raw materials which are suitable for the manufacture of articles required in a modern civilized community. In 1903 the value of earthenware and porcelain imported amounted to £187,390; of earthenware piping, £6,659; of clay, £6,186; and of bricks and tiles, £38,618.

Copper-ores.

Copper was formerly smelted in considerable quantities in South India, in Rajputana and at various parts of the outer Himalayas where a killas-like rock persists along the whole range, and is known to be copper-bearing in Kulu, Garhwal, Nepal, Sikkim, and Bhutan. Native-made copper has, however, completely given way to the imported material, and all attempts by European companies to open up the deposits have proved to be unsuccessful so far. Mining leases are still held, and prospecting licenses frequently granted for copper-ores. The Indian purchases of copper and brass form a sensible item in the imports of metals. During the six years under review the average annual value of copper imported was £813,701, whilst during the last three years the copper imported was valued at over a million sterling per annum.

Corundum.

The use of abrasives in manufacturing communities seems to be on the increase, and new forms are being put on the market yearly. Emery formerly served most requirements, until purer forms of corundum were discovered in quantity. The cheaper forms of garnet have long been used to adulterate emery, and members of the spinel family, like hercynite, have been used inadvertently as such. During the last ten years carborundum, manufactured by the cheap electrical power developed in America, has come into use, the production of the United States having now reached about 1,700 tons a year. Artificial corundum is also being manufactured from bauxite at Niagara, and crushed steel is being used to an increasing extent.

Natural corundum has thus many competitors in the market of abrasive materials, and as a large portion of the alumina in igneous magmas is necessarily used up during the processes of consolidation by the silica and bases present, it is theoretically unlikely that the free oxide can exist anywhere in an abundance comparable to the vast quantities of combined alumina in the earth's crust. In most cases the corundum is scattered as isolated crystals through the rock, and only the most economical devices for its separation can make mining remunerative.

In India, where the use of corundum by the old *saikalgar* (armourer, sword-grinder) and lapidary has been known for many generations, the requirements of the country have been met by a few comparatively rich deposits, but it is doubtful if these are worth working for export in the face of the competition referred to above in Europe and America, or will even stand against the importation of cheap abrasives.

There is still, and for many generations has been, a certain trade in Indian corundum, but the returns for production are manifestly incomplete. No workings exist of the kind that could be ordinarily described as mining, but attempts have been made to increase the scale of operations at Palakod and Paparapatti in the Salem district, near Hunsur in Mysore, and in South Rewa. In 1898, the figures returned showed a production of 7,603 cwt., but the output never approached this figure in any subsequent year.

Corundum is very widely distributed throughout the Mysore State, and is said to occur in every district except Shimoga. The annual production in Mysore has been estimated as follows:—

			£
1898	2,937 cwts.,	valued at	698
1899	879 "	" "	171
1900	1,386 "	" "	225
1901	1,634 "	" "	357
1902	574 "	" "	108

Much of the corundum, which is a regular item of trade in the bazars of cities like Delhi, Agra and Jaipur, where the Indian lapidary still flourishes, is collected in a casual way by agriculturists and cow-herds, who dispose of it through the village *bania* to the larger dealers of the great cities. Our information as to the mode of occurrence and distribution of the mineral was summarized in a special memoir published by the Geological Survey in 1898.

Since that year interesting developments have occurred in working the corundum in Ontario, Canada, where the mineral occurs in association with nepheline-syenite like that near Kangayam in the Coimbatore district.[1] By the adoption of mechanical means for concentration it has become possible to separate corundum from the felspar rock in which it is embedded, and to put a product on the market, not only for local use, but for export to the United States and Europe. The output of Canadian corundum in 1902 reached 805 tons, which was about double the production of 1901.

Gem-stones.

The most valuable of the precious stones raised in India is undoubtedly the ruby, but this and the other stones obtained in the country do not approach in value the unset stones and pearls imported, which, during the period under review, had an average annual value of £511,206.

Of the precious and semi-precious stones in India, the most important, Amber, Jadeite and Ruby, have been already referred to. Of

[1] T. H. Holland: The Sivamalai series of Elæolite and Corundum-Syenites, *Mem. Geol. Surv., Ind.*, XXX, pt. 3, 1901.

the others, the only ones which are of immediate concern are Beryl, Diamond, Garnet, Sapphire, Spinel, Tourmaline, and Turquois. All of these except the last have been, or are still being, worked to some extent in India, and the Turquois may be dismissed with the mere mention of the fact that India, besides being a large importer for local use, is one of the channels by which the material raised in Persia and adjoining areas reaches the European and Eastern market. The other minerals deserve more particular mention.

Agate.

There is still a considerable trade in agate and the related forms of silica, known under the general name of *hakik*, and obtained from the amygdaloidal flows of the Deccan Trap. The best known and perhaps still the most important of the places at which agate and carnelians are cut and prepared for the market is Cambay, the chief city of the state of that name under the Kaira Political Agency, Bombay Presidency. The agates come from various states and districts on or near the edge of the trap, but mostly from the State of Rajpipla, where the chief source is a conglomerate near the village of Ratanpur. The right to collect *hakik* at Ratanpur is leased for a period of five years at a fixed annual rental, but precise data as to the value of the stones sent to Cambay are not obtainable. A certain amount of agate-cutting is also carried on at Jabalpur, and at a few other places within range of the Deccan Trap.

Much of the agate retailed in Europe is sent from Cambay, and large quantities are also exported to China.

Rock-crystal.

In the Tanjore district, Madras Presidency, fragments of rock-crystal are collected and cut for cheap jewellery, being known as "Vallum diamonds," whilst the bi-pyramidal quartz-crystals found in the gypsum of the salt marl near Kalabagh, on the Indus, are to a certain extent used for making necklaces, and rock-crystal is similarly used for cheap jewellery in Kashmir.

Beryl.

Beryl in its pale-coloured varieties is of common occurrence in the granite-pegmatites of India, but the crystals are generally too much fissured for use as gem-stones. Occasionally in the pegmatite veins which are worked for mica in Behar and in Nellore, large crystals of beryl, many inches across, are found to include clear fragments which might be cut as aqua-marines; but the only places in India where attempts have been made to excavate pegmatite solely for its aqua marines are at Padyur (Pattalai) near Kangayam, Coimbatore district, and at different places in the Toda hills in Rajputana. Stones of considerable value were obtained from the mine which was worked at Padyur in the early part of the nineteenth century: a pit some 30—40 feet in depth is still in existence, but no one seems to have taken an interest in the place since J. M. Heath held a lease in 1818. The whole area is impregnated with igneous intrusions, and deserves more attention than it has so far received.

Diamonds: Distribution of, in India.

Notwithstanding the reputation (stretching back even as far as Ptolemy in the European, and further in the Hindu, classics) which India has had as a diamond-producing country, the output of to-day is very small and comparatively unimportant. The places which, according to accounts, have been most productive in the past form three great groups, each in association with the old unfossiliferous rocks of probably pre-Cambrian age now known as the Purána group, and distinguished locally as the Cuddapah and Kurnool systems in South India, and as the Vindhyan system in the northern part of the Peninsula.

Southern group of occurrences.

The southern of the three groups of diamond-occurrences includes localities, with apparently authentic records, in the districts of Cuddapah, Bellary, Kurnool, Kistna, and Godavari. Loose stones have been picked up on the surface of the ground, found in deposits of alluvium and in workings which have been undertaken in the so-called Banaganpilly stage of the Kurnool series of strata.

Eastern group of occurrences.

In the second group of occurrences in the Mahanadi valley, the stones have been found in the alluvium of the Sambalpur and Chanda districts, and though strata similar to those of the Vindhyans and Kurnools are known in this area, no diamonds have been found in these older rocks.

Central Indian occurrences.

The third group of occurrences occupies a tract some sixty miles long by ten miles wide, with the Vindhyan conglomerates near Panna as the centre. The diamond-mining industry still persists in this area, both in the old conglomerate of Vindhyan age, and in deposits which, though described as alluvium, are possibly relics of Lameta (Upper Cretaceous) deposits.

Garnet.

The only garnets worked to any considerable extent in India occur in the mica schists of Rajmahal in Jaipur, and near Sarwar in the adjoining State of Kishengarh.

Returns are not available to show the condition of the industry in Jaipur, but there is still a considerable industry in the Kishengarh State, though the yearly estimates are altogether too variable to permit of a fair average being drawn, varying from about £10,000 to £2,000.

Sapphire. Sapphires of considerable value were formerly obtained in Zanskar, Kashmir State, but the mines are said to be exhausted, and returns for recent work are not available. Occasionally the normal blue sapphire, and the rarer green, yellow and white varieties are found in the ruby-bearing gravels in Burma.

Spinel. Spinel is a constant associate of the ruby, both in the gravels and in the limestone, and the crystals, on account of their perfect ruby colour and their octahedral habit, are often mistaken for the true ruby with its eight-faced combination of the basal plane and rhombohedron.

Tourmaline. Several attempts have been made to work the beautiful red variety of tourmaline (rubellite) which occurs in the Ruby Mines district of Upper Burma. In 1898 an out-turn worth £359 was reported for this area, in 1900 the value was estimated at £1,240, and in 1903 at £196, but returns are not available for 1899 and 1902.

Gypsum. Gypsum occurs in considerable abundance in various parts of India, occurring both in the fibrous form and as clear selenite crystals. In Sind it occurs in beds sometimes 3 to 4 feet thick near the top of the Gáj beds of the Kirthar range; in Cutch it occurs in abundance in the rocks below the Nummulitic limestones; in the Salt Range it occurs in large masses with the salt-marl, lying below Cambrian beds. A very interesting, and, judging by the returns, important occurrence is N.-N.-W. of Nagore in Jodhpur, Rajputana, where a bed, 5 feet thick or more, occurs in silt probably formed in an old salt-lake. From this area an annual average output of 5,394 tons is reported for the years 1898 to 1903. Selenite crystals of similar origin have been recently found in the kankar near the base of the silt in the Sambhar lake.

Glass-making Materials.

The common, impure sands of the rivers and the efflorescent alkali salts, so common in many parts of India, are used in various places for the manufacture of the inferior varieties of glass used for bangles; but attempts to make the better kinds of glass on a large scale have hitherto failed in India.

The chief difficulty in the way of manufacturing the better grades of glass in India is the absence of known deposits of quartz-sand of the requisite purity and of suitable texture. For the finer qualities of glass, the sand which is, of course, the chief natural substance used, should be rather fine and uniform in grain, angular rather than rounded, and perfectly white. For the commoner kinds of glass, in which colour is of no importance, a considerable quantity of impurity can be tolerated and allowed for in making up the melting charge. The well-known Fontainebleau sand of France, used largely for glass-making, will yield as much as 99 per cent. of silica, with 0·50 per cent. of alumina and a trace of iron oxide; but good window glass can be made from sand containing iron oxide up to ·02 per cent. without the use of the corrective manganese oxide.

To what extent a glass-making industry would find a market in India may be judged by the fact that during the past six years the annual imports of glass and glassware have gradually risen in value from £441,529 in 1898-99 to £661,377 in 1903-04.

Lead, Silver, and Zinc.

Galena alone, or with blende and other sulphide ores, is known in various parts of India and Burma, and has been worked in various places for lead, or lead and silver, under past Native rulers; but the mining of lead-ores has long been extinct, and the only recent attempt calling for special mention is that now being made to develope the deposits near Pang Yung in the Northern Shan States formerly worked by the Chinese, who left behind large heaps of slag reported to be amenable to profitable treatment by modern metallurgical processes for the extraction of silver.

Millstones.

The manufacture of millstones is almost universal in India, any local hard stone being turned to account. On the plains small millstones of about 15 inches in diameter are worked by hand, but in the Himalayas, where a fall of water can be easily arranged, a rude form of turbine is made to work a heavier stone by a direct-acting vertical shaft, and the ordinary meal of the hill-man is manufactured in these primitive mills. These small mills are familiar objects in a Himalayan valley, but no returns are available to gauge the industry of stone-cutting.

Mineral Paints.

Up to the present the manufacture of mineral paints appears to be very small compared to the demand and the natural resources in minerals apparently suitable. In the Jabalpur district mineral paint-works are utilizing the soft hematites of Jauli and are drawing supplies of yellow ochre from the Panna State, whilst similar works near Calcutta are dependent largely on imported material.

Ochres, red, yellow and of other colours, are commonly used by natives in many parts of the country, in a crude or simply levigated form and are known under the generic name *geru*. A common source of supply is the laterite in the Peninsula and Burma, but well-defined ochres occur in deposits of various geological ages down to the Archæan hematites. In Trichinopoly district yellow ochre is obtained from the Cretaceous rocks, and in Burma large deposits are known amongst the Tertiary beds of the Myingyan district. A black slate near Kishengarh has been successfully tried on the Rajputana-Malwa Railway. Barytes, used as a substitute or adulterant for "white lead," is obtainable in quantity near Alangayam in the Salem district and in the Jabalpur district, but no attempts have been made to turn the deposits to account for paint-making.

Orpiment, the yellow sulphide of arsenic, has been already referred to under "Arsenic" (*supra*, p. 97.)

Mineral Waters.

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 water is 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. Generally it may be said that 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 (and perhaps dependent on similar causes) to the distribution of petroleum, with its constant associates of salt and gypsum. Other springs occur along the foot-hills of the Himalayas, in the Kharakhpur hills, etc., sufficiently well distributed to permit of easy transport. The provincial gazetteers contain sufficient references to these springs to guide private enterprise, but more might be done in the way of analysis of the waters, which would be as interesting from a scientific as possibly from an economic point of view. The mineral water of Sitakhund in the Kharakhpur hills is the only one which has been turned to account.

Phosphates.

One regretful feature in connection with the Indian mineral resources is the absence, in a country where agriculture is such a predominant industry, of any phosphatic deposits of value, and a further circumstance to be regretted is the continued export of phosphates in the form of bones, due primarily to the fact that, being without means for the manufacture of cheap sulphuric acid, superphosphates are not made in the country, and the little that is used is imported from Europe. During the past six years the materials imported under the head of manures have varied in value from £6,367 in 1898-99 to £2,144 in

1902-03, whilst the exports of manures, amongst which bones make up 99 per cent. of the total, have been as follows:—

TABLE 60.—*Exports of Manures from India during the years 1897-98 to 1902-03.*

YEAR.	Quantity.	Value.
	Tons.	£
1897-98	72,664	263,500
1898-99	74,971	272,268
1899-00	110,927	408,581
1900-01	113,465	394,228
1901-02	94,243	344,128
1902-03	105,634	381,784
Average	*95,317*	*344,081*

Amongst the phosphatic deposits of India, the principal and perhaps the only one worth considering is the deposit of phosphatic nodules of the septarian kind, occurring in the Cretaceous beds of the Perambalur taluk, Trichinopoly district, Madras Presidency. Dr. H. Warth in 1893 estimated that to a depth of 200 feet the beds contained phosphates to the amount of about 8 million tons, but the nodules are distributed irregularly through clay, varying, in the different deep excavations made, between 27 and 47 lbs. per 100 cubic feet, and in some shallow diggings 70 lbs. per 100 cubic feet. Analyses of these nodules show them to contain from 56 to 59 per cent. of phosphate, and about 16 per cent. of carbonate of lime, with considerable variations in different nodules. The alumina and oxide of iron vary between 4 and 8 per cent.

Two attempts made to dispose of these phosphates in a finely powdered condition for use as a fertilizer on coffee plantations in South India were reported to be unprofitable, and mining leases have consequently not been applied for. No attempts have been made to export the material. Its value would possibly be about the same as a third-grade Algerian phosphate, which brings about £1 a ton delivered at European ports, and as the sea freight from Madras would be added to the cost of a railway journey of 248 miles and cartage of 20 miles, there is no present prospect of profitable mining for export.

Small quantities of apatite are turned out and thrown away with the waste in the Hazaribagh and Nellore mica-mining areas, and a few other occurrences of unknown, and presumably smaller, value have been reported at different places—near Mussoorie, in East Berar, and in the eocene shales above the coal near Dandot colliery in the Punjab Salt Range.

Rare Minerals.

Minerals of the so-called rare metals have received hitherto practically no attention in India, although some are known to exist in the country, and others, judging by the geological conditions, might be hopefully searched for. Molybdenite has been found as isolated crystals in pegmatite and quartz-veins in parts of Chota Nagpur; tungsten occurs in the mineral wolfram as a common associate of tin-ores in South Burma and in the Southern Shan States; platinum and iridium have been found in the auriferous gravels of the rivers draining the slopes of the Patkoi ranges, both on the Assam and the Burma sides; uranium-ores have been detected in the mica-bearing pegmatites of the Singar mica mine in the Gaya district, occurring as pitchblende, torbernite and uranium-ochre; titanium is widely distributed in the form of ilmenite and sphene; and zircon occurs associated with the elæolite-syenites in the Coimbatore district. Of these minerals possibly the wolfram (tungstic ore) of Burma offers the best prospects of immediate development.

No undoubted occurrence has been recorded of the minerals which are valuable, like monazite and the new Ceylon mineral thorianite, on account of the incandescent rare earths they contain, although some of these minerals are very widely distributed amongst crystalline rocks resembling those of Peninsular India. Columbite, tscheffkinite, gadolinite, and allanite containing helium have, however, been definitely determined in India.

Slate.

Slate-quarrying gives a means of livelihood to numbers of workers along the outer Himalayas, where the foliated rocks, though often not true clay slates, possess an even and perfect fissility which enables them to be split for slabs and even fine roofing slates. In the Kangra district a joint-stock company has organized the work in a systematic manner, and for the past six years has declared dividends of 12 per cent. with the addition of considerable sums to the reserve funds. The same company works quarries in clay-slate amongst the Aravalli series near Rewari, south of Delhi.

In the Kharakpur hills, a private company is working a slightly metamorphosed phyllite, which, though not giving the thinnest varieties of roofing slate, produces fine slabs, for which a more extended use is continually being found. Slate is also being worked in various parts of the so-called transition series of rocks on the Peninsula; but no figures are available to show the extent of the trade.

Sodium Compounds.

Besides sodium chloride other salts of soda, notably the sulphate (*khari*) and carbonate (*sajji*), accumulate in the soil of areas where the climate is dry, and both the sulphate and carbonate are prominent amongst the sodic compounds in the brine of the Rajputana salt lakes. A conspicuous instance of a salt lake in which the carbonate is most prominent is the crater-like Lonar lake occurring as a roughly circular depression in the Deccan trap-flows of Berar.

Besides the impure *sajji-matti*, of which considerable quantities are still in use, the trade statistics show that imports are distinctly increasing, and that common country *sajji* is becoming displaced. For information concerning the alkali compounds used and manufactured in India, see *Agricultural Ledger*, No. 5 of 1902, published by the Reporter on Economic Products, Calcutta.

Steatite.

One of the most widely distributed minerals in India is steatite, either in the form of a coarse potstone—so-called on account of its general use in making pots, dishes, etc.,—or in the more compact form suitable for carvings, and in its best form, suitable for the manufacture of gas-burners. There is a trade of undetermined value in nearly every province, but it is impossible to form even a rough estimate of its value. An exhaustive account of the Indian occurrences of steatite was published by Mr. F. R. Mallet in the *Records*, *Geological Survey of India*, vol. XXII, part 2 (1889), and a note by Mr. H. H. Hayden in vol. XXIX (p. 71) of the same publication adds further details with regard to the deposits in Minbu district, Burma, where the annual outturn is estimated to be worth from £300 to £500. The returns, which are confessedly incomplete, give an average annual production in India of about 35,000 tons, valued at £1,900.

Sulphur, Sulphuric Acid, and Soluble Sulphates.

Sulphur.

Small quantities of sulphur are obtainable on the dying volcano of Barren Island, and on some of the volcanoes in Western Baluchistan, whilst it has been reported in connection with the petroliferous Tertiary rocks in the Baluchistan-Persian belt, as well as in the Arakan system on the east. There are, however, no deposits of free sulphur known to be worth working.

Pyrite is known in various parts of India, and in one place, near Kalabagh on the Indus, it is sufficiently abundant in the shales which have been worked for alum to give rise to frequent cases of spontaneous combustion. An occurrence of this sort is one that, suitably placed, might be of value as a source of sulphur. Otherwise, the only chance of sulphur to compete with the imported article is bound up in the problem of developing the metalliferous sulphides for both metal and sulphur.

Sulphuric acid.

In view of the value of the imports of sulphur and sulphuric acid, and in consideration of the fact that a cheap supply of the acid would be the key to many industries now either non-existent or in a feeble condition, the manufacture of sulphuric acid on a large scale and cheaply would be the starting point of an economic revival. During the six years under review the imports of sulphur averaged 34,136 cwts. a year, valued at £12,612, whilst the annual average for sulphuric acid was 45,374 cwts., valued at £32,273. A small quantity of the acid, on an average 250 cwts. a year, was re-exported, chiefly to British East Africa. In addition to sulphuric acid, there are several chemicals imported which could be produced in India more cheaply if the acid were made in the country in large quantities at a sufficiently low price. The average annual value of imported "chemicals for paper-making" alone has been £54,810 during the past six years, and if, as seems likely, an attempt is made to turn the bye-products in coke-making to account, the demand for sulphuric acid will increase, whilst the only chance of these industries springing up will depend on the possibility of obtaining a cheap supply of sulphuric acid.

Sulphates of iron and copper.

For many years pyritous deposits in India have been turned to account for the manufacture of soluble sulphates of iron and copper. The case of alum has been referred to already (*supra*, p. 94), and with the alum, which was formerly obtained in quantity from the decomposed pyritous shales at Khetri and Singhana in Rajputana, copperas and blue vitriol were also obtained. No statistics are, however, available with regard to the history of these industries, which have had to give way to the importation of cheap chemicals from Europe.

Through the accident of an alphabetical arrangement, the last subject to be considered enables us to point the lesson taught by a general survey of progress (*cf.* page 7). Sulphuric acid is the key to most chemical and to many metallurgical industries; it is essential for the manufacture of superphosphates, the purification of mineral oils and the production of ammonium sulphate, various acids, and a host of minor products; it is a necessary link in the chain of operations involved in the manufacture of the alkalies, with which are bound up the industries of making soap, glass, paper, oils, dyes and colouring matters; and, as a bye-product, it permits the remunerative smelting of ores which it would be impossible otherwise to develop. During the last hundred years the cost of a ton of sulphuric acid in England has been reduced from over £30 to under £2, and it is in consequence of the attendant revolution in the European chemical industries, aided by increased facilities for transport, that in India the manufacture of alum, copperas, blue vitriol and the alkalies have been all but exterminated; that the export trade in nitre has been reduced instead of developed; that copper and several other metals are no longer smelted; that the country is robbed every year of nearly 100,000 tons of phosphatic fertilizers; and that it is compelled to pay over 10 million sterling for products obtained in Europe from minerals identical with those lying idle in India.

Although sulphuric acid and the alkalies are essential to so many other industries, the conditions for their profitable manufacture will balance the "protective" effect of transport charges only when there is a market in the country for the bye-products which are now essential parts of the cycle of operations in a chemical industry. These conditions, as shown by the import statistics, are rapidly ripening, but the enterprising capitalist should remember, also, that the present requirements of India represent but a fraction of the consumption which will follow any material reduction in prices by local production.

LIST OF PLATES.

PLATE 1.—Diagram showing the imports of foreign and the exports of Indian coal in statute tons during the decade 1894–1903.

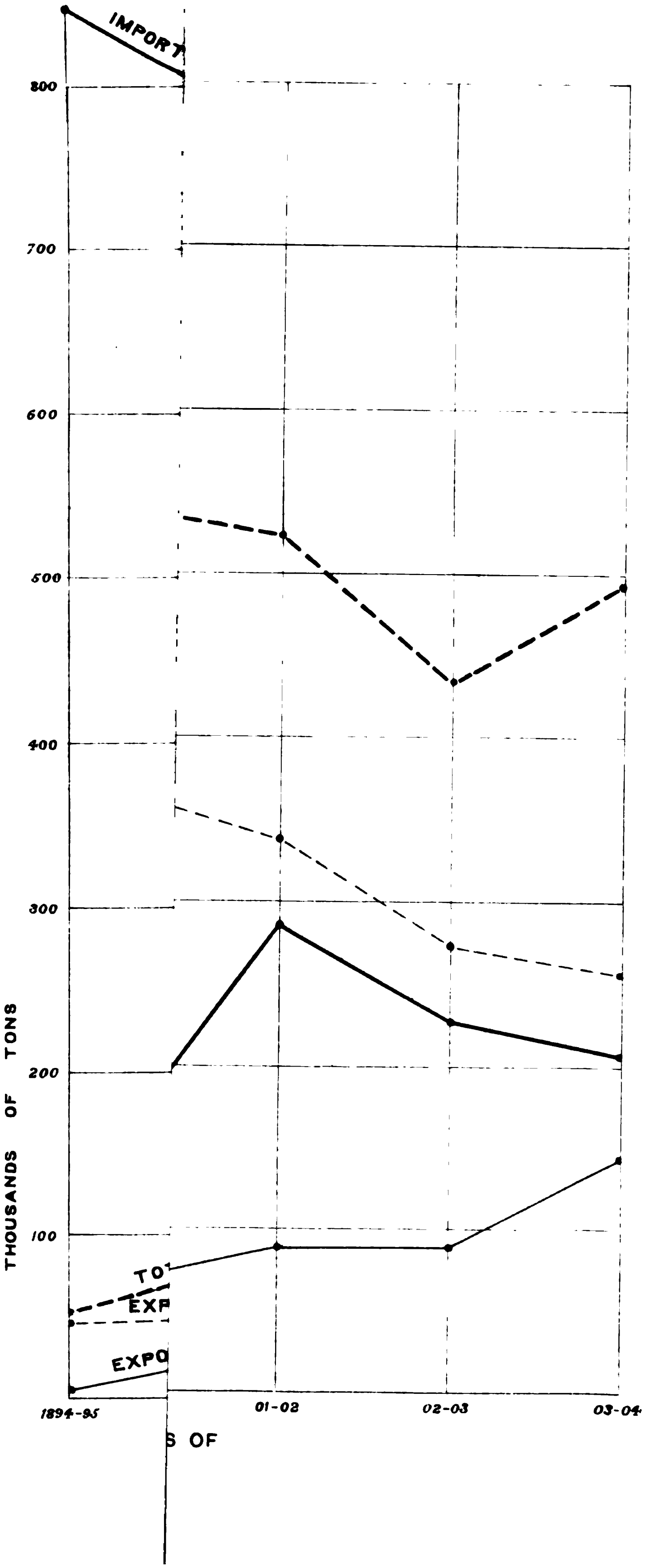
PLATE 2.—Diagram showing the provincial output of coal in statute tons for the years 1884—1903. The output for Bengal is necessarily omitted from a diagram on this scale, but is shown in figure 1, p. 9.

PLATE 3.—Progress of the Warora colliery since the commencement in 1871. For details of the last six years, see p 32.

PLATE 4.—Output of the principal salt-producing countries. The information for Foreign countries has been obtained mainly from *Mineral Industry*.

PLATE 5.—Production of the Upper Burma oil-fields for the decade 1894—1903, stated in Imperial gallons.

PLATE 6.—Map showing the occurrences of petroleum in Assam and Burma, prepared by Mr. T. D. LaTouche, B.A., F.G.S., Superintendent, Geological Survey of India.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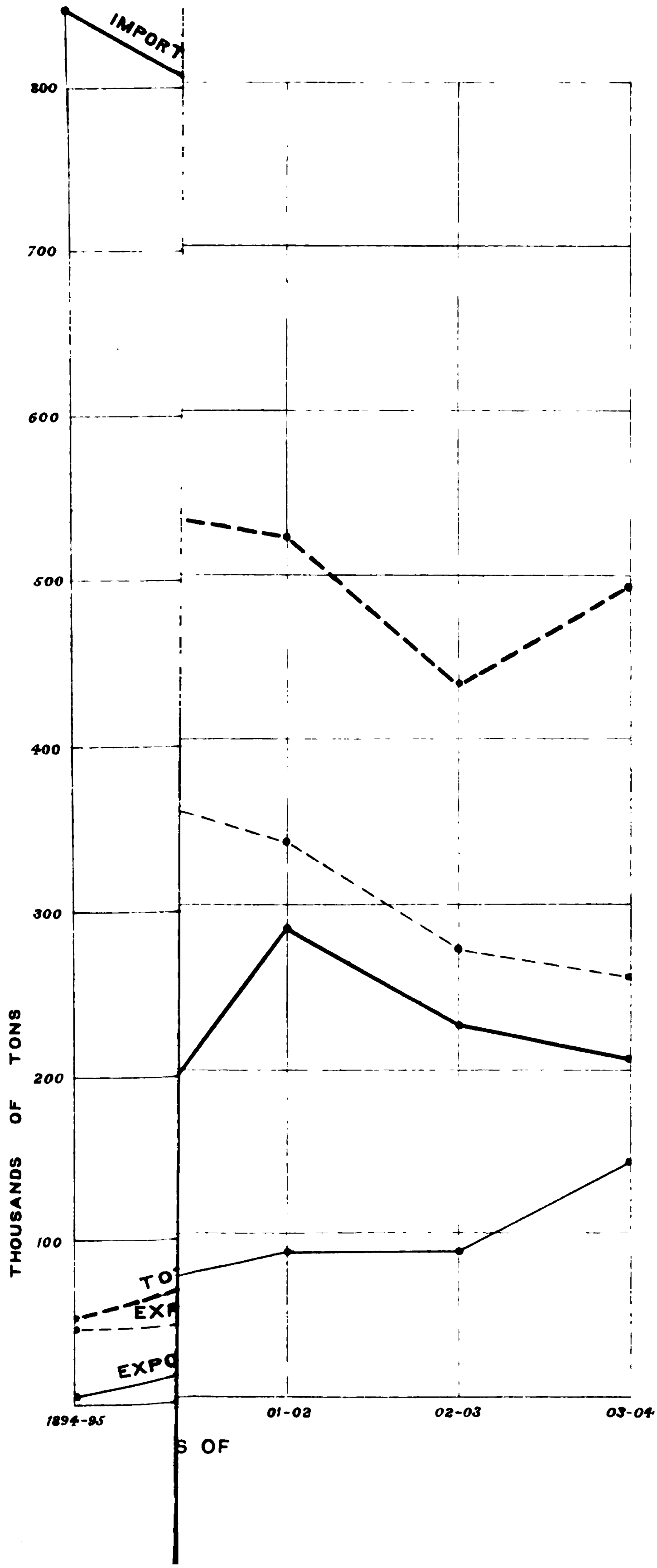
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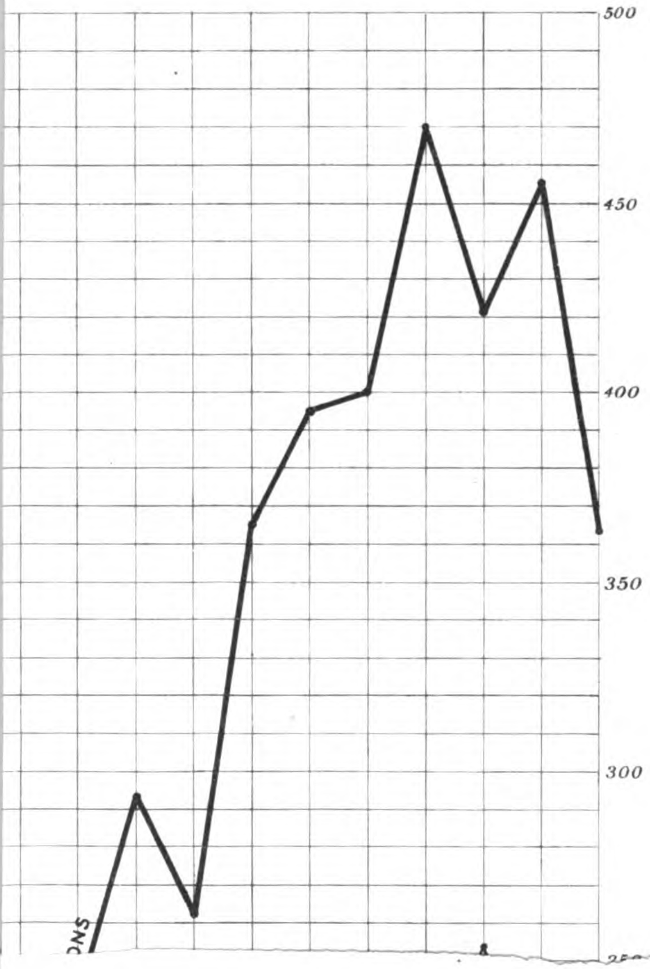

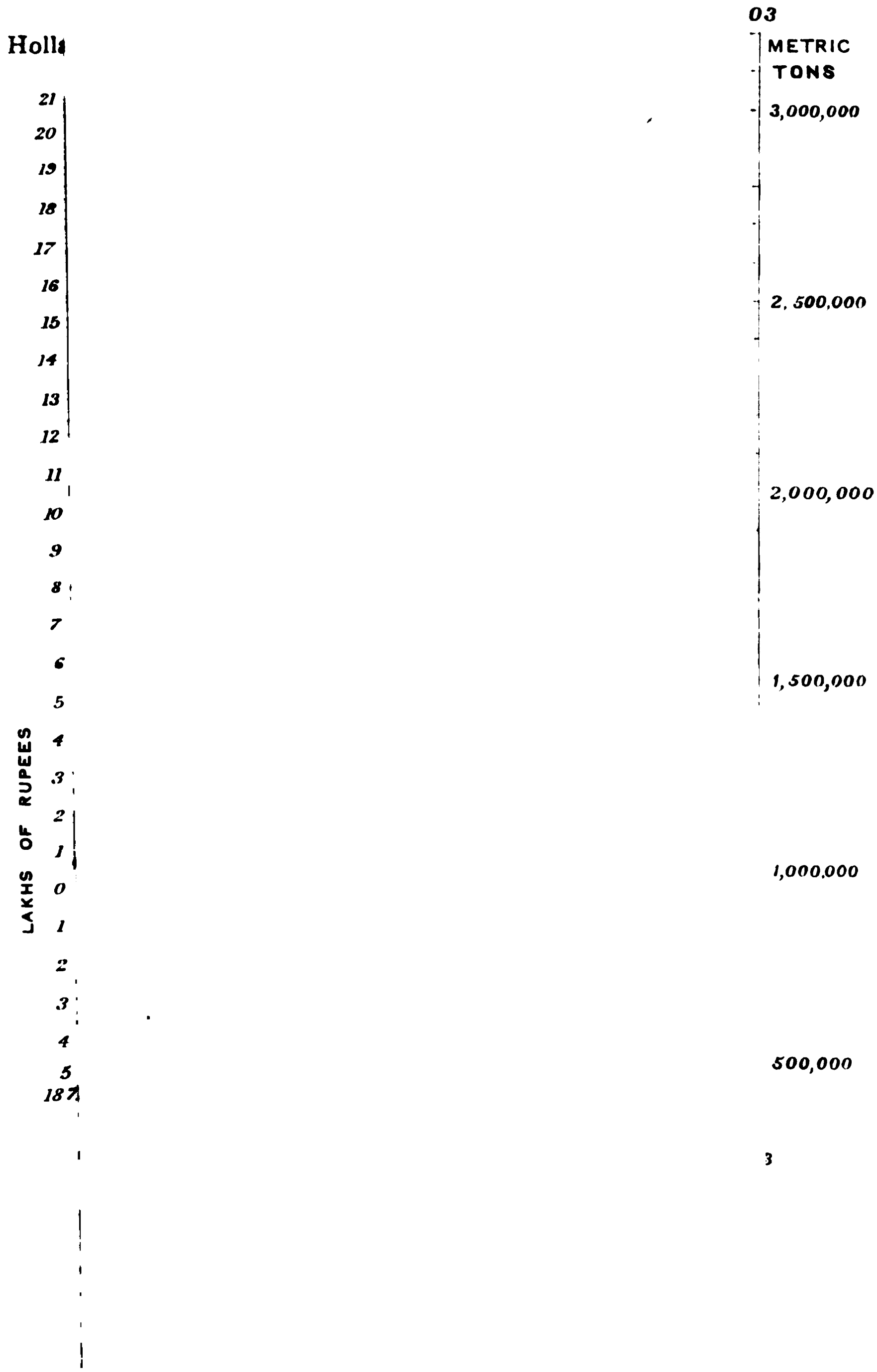
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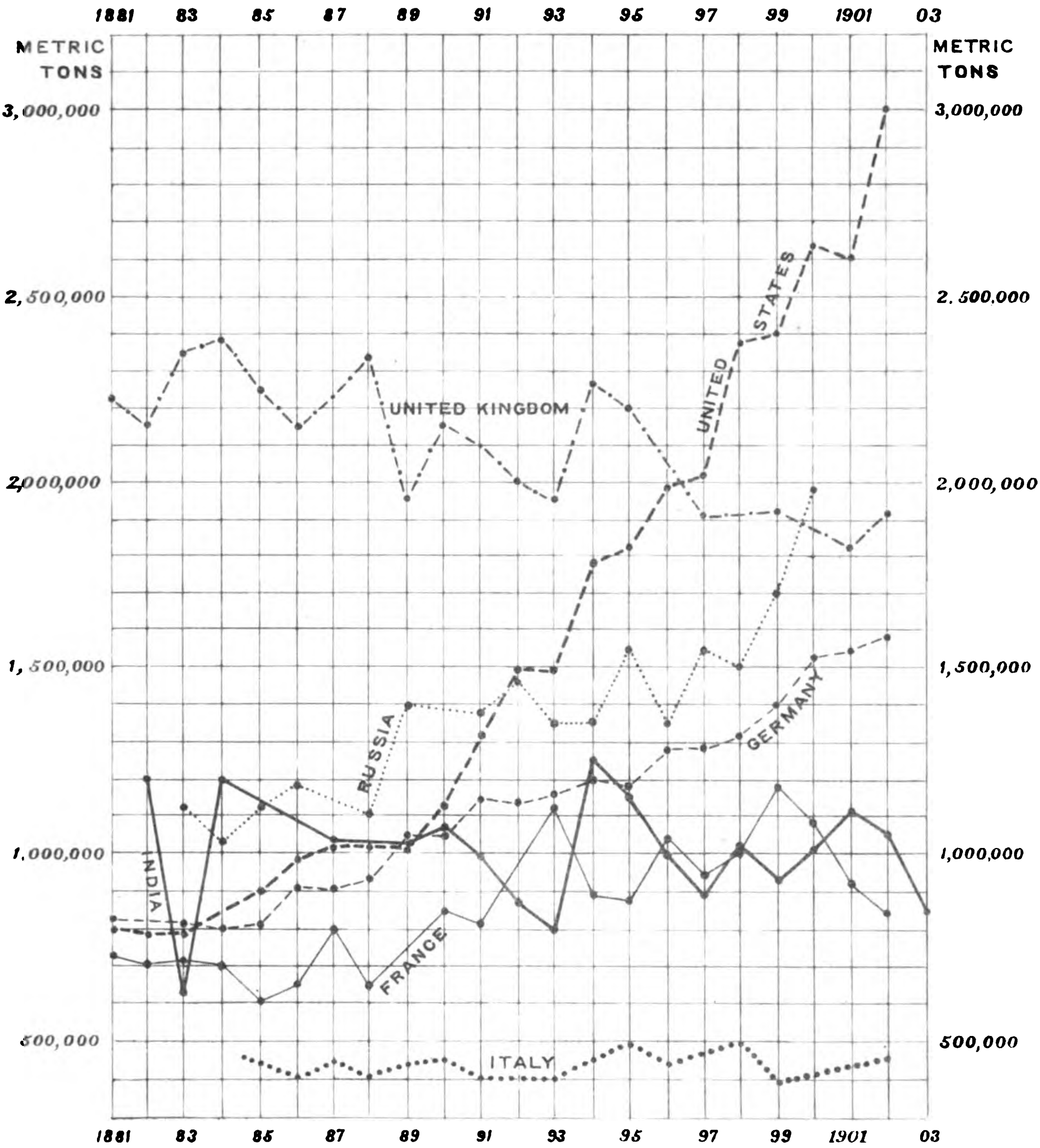
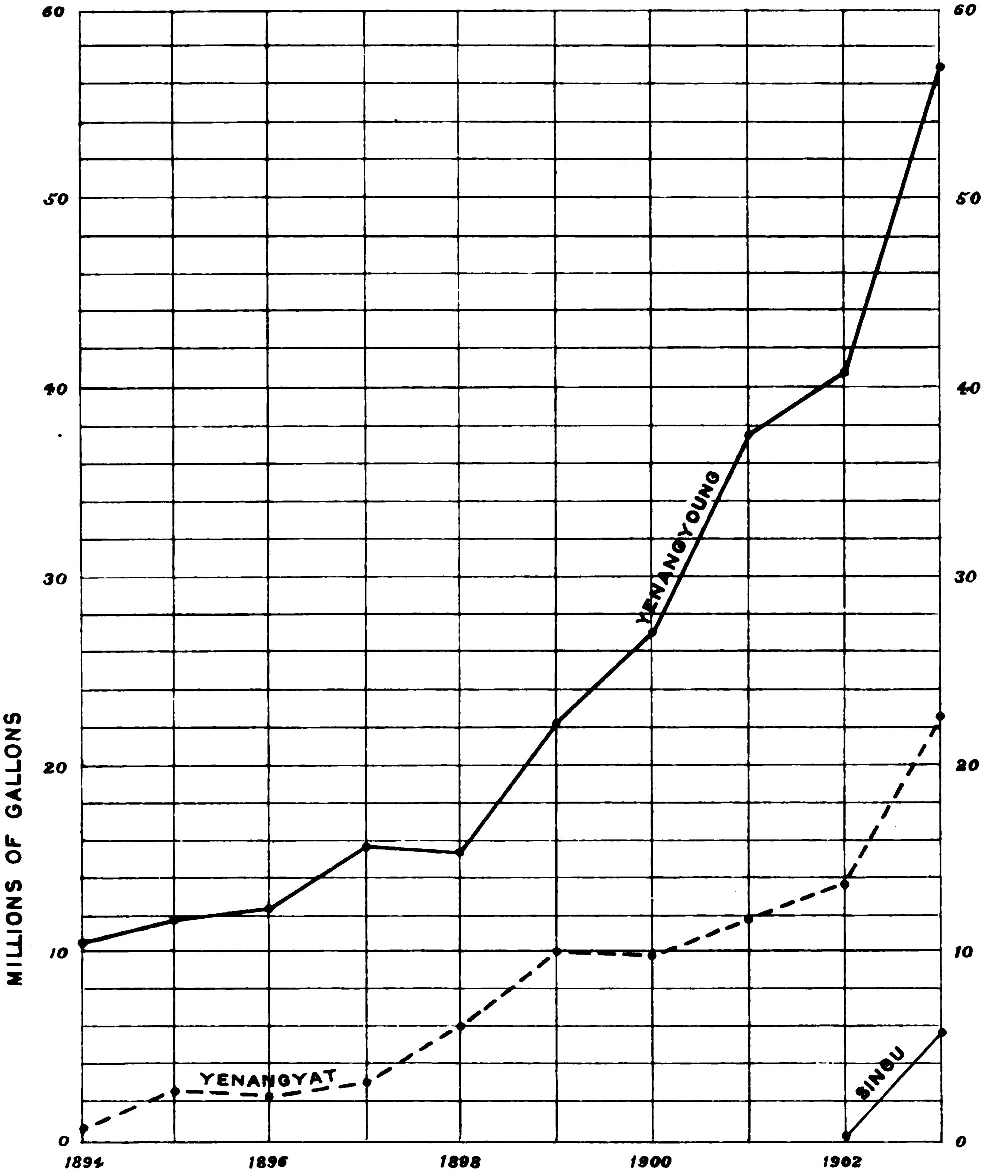
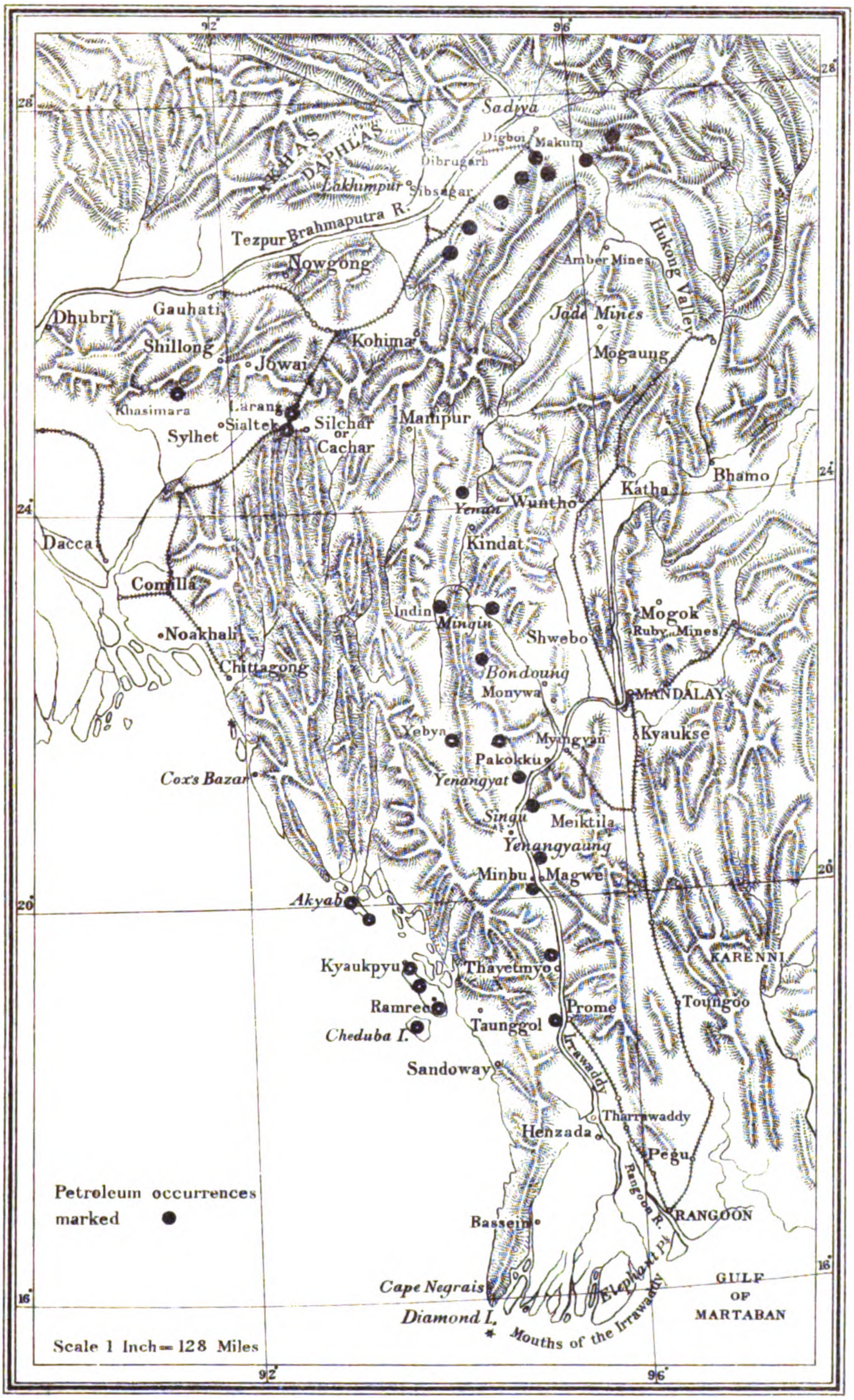


OUTPUT OF PRINCIPAL SALT-PRODUCING COUNTRIES.



PRODUCTION OF UPPER BURMAH OILFIELDS.



OCCURRENCES OF PETROLEUM IN ASSAM AND BURMA.

Part 3.—Note on the progress of the gold industry in Wynaad, Nilgiri district. Notes on the representatives of the Upper Gondwana series in Trichinopoly and Nellore-Kistna districts. Senarmontite from Sarawak.

Part 4.—On the geographical distribution of fossil organisms in India. Submerged forest on Bombay Island.

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Part 1.—Annual report for 1878. Geology of Kashmir (third notice). Further notices of Siwalik mammalia. Notes on some Siwalik birds. Notes of a tour through Hangrang and Spiti. On a recent mud eruption in Ramri Island (Arakan). On Braunite, with Rhodonite, from near Nagpur, Central Provinces. Palæontological notes from the Satpura coal-basin. Statistics of coal importations into India.

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Part 3.—On the geological features of the northern part of Madura district, the Pudukota State, and the southern parts of the Tanjore and Trichinopoly districts included within the limits of sheet 80 of the Indian Atlas. Rough notes on the cretaceous fossils from Trichinopoly district, collected in 1877-78. Notes on the genus Sphenophyllum and other Equisetaceæ, with reference to the Indian form Trizygia Speciosa, Royle (Sphenophyllum Trizygia, Ung.). On Mysorin and Atacamite from the Nellore district. On corundum from the Khasi Hills. On the Joga neighbourhood and old mines on the Nerbudda.

Part 4.—On the 'Attock Slates' and their probable geological position. On a marginal bone of an undescribed tortoise, from the Upper Siwaliks, near Nila, in the Potwar, Punjab. Sketch of the geology of North Arcot district. On the continuation of the road section from Murree to Abbottabad.

Vol. XIII, 1880.

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Part 2.—Geological notes. Palæontological notes on the lower trias of the Himalayas. On the artesian wells at Pondicherry, and the possibility of finding such sources of water-supply at Madrás.

Part 3.—The Kumaun lakes. On the discovery of a celt of palæolithic type in the Punjab. Palæontological notes from the Karharbari and South Rewah coal-fields. Further notes on the correlation of the Gondwana flora with other floras. Additional note on the artesian wells at Pondicherry. Salt in Rajputana. Record of gas and mud eruptions on the Arakan coast on 12th March 1879 and in June 1843.

Part 4.—On some pleistocene deposits of the Northern Punjab, and the evidence they afford of an extreme climate during a portion of that period. Useful minerals of the Arvali region. Further notes on the correlation of the Gondwana flora with that of the Australian coal-bearing system. Note on reh or alkali soils and saline well waters. The re-soils of Upper India. Note on the Naini Tal landslip, 18th September 1880.

Vol. XIV, 1881.

Part 1.—Annual report for 1880. Geology of part of Dardistan, Baltistan, and neighbouring districts, being fifth notice of the geology of Kashmir and neighbouring territories. Note on some Siwalik carnivora. The Siwalik group of the Sub-Himalayan region. On the South Rewah Gondwana basin. On the ferruginous beds associated with the basaltic rocks of north-eastern Ulster, in relation to Indian laterite. On some Rajmahal plants. Travelled blocks of the Punjab. Appendix to 'Palæontological notes on the lower trias of the Himalayas.' On some mammalian fossils from Perim Island, in the collection of the Bombay Branch of the Royal Asiatic Society.

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Part 2.—The Nahan-Siwalik unconformity in the North-western Himalaya. On some Gondwana vertebrates. On the ossiferous beds of Hundes in Tibet. Notes on mining records, and the mining record office of Great Britain; and the Coal and Metalliferous Mines Acts of 1872 (England). On cobaltite and danaite from the Khetri mines, Rajputana; with some remarks on Jaipurite (Syepoorite). On the occurrence of zinc ore (Smithsonite and Blende) with barytes, in the Karnul district, Madras. Notice of a mud eruption in the island of Cheduba.

Part 3.—Artesian borings in India. On oligoclase granite at Wangtu on the Sutlej, North-west Himalayas. On a fish-palate from the Siwaliks. Palæontological notes from the Hazaribagh and Lohardagga districts. Undescribed fossil carnivora from the Siwalik hills in the collection of the British Museum.

Part 4.—Remarks on the unification of geological nomenclature and cartography. On the geology of the Arvali region, central and eastern. On a specimen of native antimony obtained at Pulo Obin, near Singapore. On Turgite from the neighbourhood of Juggiapett, Kistnah district, and on zinc carbonate from Karnul, Madras. Note on the section from Dalhousie to Pangi, *viâ* the Sach Pass. On the South Rewah Gondwana basin. Submerged forest on Bombay Island.

Vol. XV, 1882.

Part 1.—Annual report for 1881. Geology of North-west Kashmir and Khagan (being sixth notice of geology of Kashmir and neighbouring territories). On some Gondwana labyrinthodonts. On some Siwalik and Jamna mammals. The geology of Dalhousie, North-west Himalaya. On remains of palm leaves from the (tertiary) Murree and Kasauli beds in India. On Iridosmine from the Noa-Dibing river, Upper Assam, and on Platinum from Chutia Nagpur. On (1) a copper mine lately opened near Yongri hill, in the Darjiling district; (2) arsenical pyrites in the same neighbourhood; (3) kaolin at Darjiling (being 3rd appendix to a report on the geology and mineral resources of the Darjiling district and the Western Duars). Analyses of coal and fire-clay from the Makum coal-field, Upper Assam. Experiments on the coal of Pind Dadun Khan, Salt-range, with reference to the production of gas, made April 29th, 1881. Report on the proceedings and result of the International Geological Congress of Bologna.

Part 2.—General sketch of the geology of the Travancore State. The Warkilli beds and reported associated deposits at Quilon, in Travancore. Note on some Siwalik and Narbada fossils. On the Coal-bearing rocks of the valleys of the Upper Rer and the Mand rivers in Western Chutia Nagpur. On the Pench river coal-field in Chhindwara district, Central Provinces. On borings for coal at Engsein, British Burma. On sapphires recently discovered in the North-west Himalaya. Notice of a recent eruption from one of the mud volcanoes in Cheduba.

Part 3.—Note on the coal of Mach (Much) in the Bolan Pass, and of Sharag or Sharigh on the Harnai route between Sibi and Quetta. New faces observed on crystals of stilbite from the Western Ghâts, Bombay. On the traps of Darang and Mandi in the North-western Himalayas. Further note on the connexion between the Hazara and the Kashmir series. On the Umaria coal-field (South Rewah Gondwana basin). The Daranggiri coal-field, Garo Hills, Assam. On the outcrops of coal in the Myanoung division of the Henzada district.

Part 4.—On a traverse across some gold-fields of Mysore. Record of borings for coal at Beddadanol, Godavari district, in 1874. Note on the supposed occurrence of coal on the Kistna.

Vol. XVI, 1883.

Part 1.—Annual report for 1882. On the genus Richthofenia, Kays (Anomia Lawrenciana, Koninck). On the geology of South Travancore. On the geology of Chamba. On the basalts of Bombay.

Part 2.—Synopsis of the fossil vertebrata of India. On the Bijori Labyrinthodont. On a skull of Hippotherium antilopinum. On the iron ores, and subsidiary materials for the manufacture of iron, in the north-eastern part of the Jabalpur district. On laterite and other manganese ore occurring at Gosulpore, Jabalpur district. Further notes on the Umaria coal-field.

Part 3.—On the microscopic structure of some Dalhousie rocks. On the lavas of Aden. On the probable occurrence of Siwalik strata in China and Japan. On the occurrence of Mastodon angustidens in India. On a traverse between Almora and Mussooree made in October 1882. On the cretaceous coal-measures at Borsora, in the Khasia Hills, near Laour, in Sylhet.

Part 4.—Palæontological notes from the Daltonganj and Hutar coal-fields in Chota Nagpur. On the altered basalts of the Dalhousie region in the North-western Himalayas. On the microscopic structure of some Sub-Himalayan rocks of tertiary age. On the geology of Jaunsar and the Lower Himalayas. On a traverse through the Eastern Khasia, Jaintia, and North Cachar Hills. On native lead from Maulmain and chromite from the Andaman Islands. Notice of a fiery eruption from one of the mud volcanoes of Cheduba Island, Arakan. Notice.—Irrigation from wells in the North-Western Provinces and Oudh.

Vol. XVII, 1884.

Part 1.—Annual report for 1883. Considerations on the smooth-water anchorages or mud banks of Narrakal and Alleppy on the Travancore coast. Rough notes on Billa Surgam and other caves in the Kurnool district. On the geology of the Chuari and Sihunta parganas of Chamba. On the occurrence of the genus Lyttonia, Waagen, in the Kuling series of Kashmir.

Part 2.—Notes on the earthquake of 31st December 1881. On the microscopic structure of some Himalayan granites and gneissose granites. Report on the Choi coal exploration. On the re-discovery of certain localities for fossils in the Siwalik beds. On some of the mineral resources of the Andaman Islands in the neighbourhood of Port Blair. The intertrappean beds in the Deccan and the Laramie group in western North America.

Part 3.—On the miscroscopic structure of some Arvali rocks. Section along the Indus from the Peshawar Valley to the Salt-range. On the selection of sites for borings in the Raigarh-Hingir coal-field (first notice). Note on lignite near Raipore, Central Provinces. The Turquoise mines of Nishâpûr, Khorassan. Notice of a further fiery eruption from the Minbyin mud volcano of Cheduba Island, Arakan. Report on the Langrin coal-field, south-west Khasia Hills. Additional notes on the Umaria coal-field.

Part 4.—On the Geology of part of the Gangasulan pargana of British Garhwal. On fragments of slates and schists imbedded in the gneissose granite and granite of the North-west Himalayas. On the geology of the Takht-i-Suleiman. On the smooth-water anchorages of the Travancore coast. On auriferous sands of the Subansiri river, Pondicherry lignite, and phosphatic rocks at Musuri. Work at the Billa Surgam caves.

Vol. XVIII, 1885.

Part 1.—Annual report for 1884. On the country between the Singareni coal-field and the Kistna river. Geological sketch of the country between the Singareni coal-field and Hyderabad. On coal and limestone in the Doigrung river, near Golaghat, Assam. Homotaxis, as illustrated from Indian formations. Afghan field notes.

Part 2.—A fossiliferous series in the Lower Himalaya, Garhwal. On the probable age of the Mandhali series in the Lower Himalaya. On a second species of Siwalik camel (Camelus Antiquus, nobis ex Falc. and Caut. MS.). On the Geology of Chamba. On the probability of obtaining water by means of artesian wells in the plains of Upper India. Further considerations upon artesian sources in the plains of Upper India. On the geology of the Aka Hills. On the alleged tendency of the Arakan mud volcanoes to burst into eruption most frequently during the rains. Analyses of phosphatic nodules and rock from Mussooree.

Part 3.—On the Geology of the Andaman Islands. On a third species of Merycopotamus. Some observations on percolation as affected by current. Notice of the Pirthalla and Chandpur meteorites. Report on the oil-wells and coal in the Thayetmyo district, British Burma. On some antimony deposits in the Maulmain district. On the Kashmir earthquake of 30th May 1885. On the Bengal earthquake of 14th July 1885.

Part 4.—Geological work in the Chhattisgarh division of the Central Provinces. On the Bengal earthquake of July 14th 1885. On the Kashmir earthquake of 30th May 1885. On the results of Mr. H. B. Foote's further excavations in the Billa Surgam caves. On the mineral hitherto known as Nepaulite. Notice of the Sabetmahet meteorite.

Vol. XIX, 1886.

Part 1.—Annual report for 1885. On the International Geological Congress of Berlin. On some Palæozoic Fossils recently collected by Dr. H. Warth, in the Olive group of the Salt-range. On the correlation of the Indian and Australian coal-bearing beds. Afghan and Persian Field notes. On the section from Simla to Wangtu, and on the petrological character of the Amphibolites and Quartz Diorites of the Sutlej valley.

Part 2.—On the Geology of parts of Bellary and Anantapur districts. Geology of the Upper Dehing basin in the Singpho Hills. On the microscopic characters of some eruptive rocks from the Central Himalayas. Preliminary note on the Mammalia of the Karnul Caves. Memorandum on the prospects of finding coal in Western Rajputana. Note on the Olive group of the Salt-range. On the discussion regarding the boulder-beds of the Salt-range. On the Gondwana Homotaxis.

Part 3.—Geological sketch of the Vizagapatam district, Madras. Preliminary note on the geology of Northern Jesalmer. On the microscopic structure of some specimens of the Malani rocks of the Arvali region. On the Malanjkhandi copper-ore in the Balaghat district, C. P.

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VOL. XX, 1887.

Part 1.—Annual report for 1886. Field-notes from Afghanistan: No. 4, from Turkistan to India. Physical geology of West British Garhwal; with notes on a route traverse through Jaunsar-Bawar and Tiri-Garhwal. On the geology of the Garo Hills. On some Indian image-stones. On soundings recently taken off Barren Island and Narcondam. On a character of the Talchir boulder-beds. Analysis of Phosphatic Nodules from the Salt-range, Punjab.

Part 2.—The fossil vertebrata of India. On the Echinoidea of the cretaceous series of the Lower Narbada Valley, with remarks upon their geological age. Field-notes: No. 5—to accompany a geological sketch map of Afghanistan and North-eastern Khorassan. On the microscopic structure of some specimens of the Rajmahal and Deccan traps. On the Dolerite of the Chor. On the identity of the Olive series in the east with the speckled sandstone in the west of the Salt-range in the Punjab.

Part 3.—The retirement of Mr. Medlicott. Notice of J. B Mushketoff's Geology of Russian Turkistan. Crystalline and metamorphic rocks of the Lower Himalaya, Garhwal, and Kumaun, Section I. Preliminary sketch of the geology of Simla and Jutogh. Note on the 'Lalitpur' meteorite.

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VOL. XXI, 1888.

Part 1.—Annual report for 1887. Crystalline and metamorphic rocks of the Lower Himalaya, Garhwal, and Kumaun, Section III. The Birds'-nest or Elephant Island, Mergui Archipelago. Memorandum on the results of an exploration of Jessalmer, with a view to the discovery of coal. A facetted pebble from the boulder bed ('speckled sandstone') of Mount Chel in the Salt-range in the Punjab. Examination of nodular stones obtained by trawling off Colombo.

Part 2.—Award of the Wollaston Gold Medal, Geological Society of London, 1888. The Dharwar System, the chief auriferous rock series in South India. On the Igneous rocks of the districts of Raipur and Balaghat, Central Provinces. On the Sangar Marg and Mehowgale coal-fields, Kashmir.

Part 3.—The Manganese Iron and Manganese Ores of Jabalpur. 'The Carboniferous Glacial Period.' The sequence and correlation of the pre-tertiary sedimentary formations of the Simla region of the Lower Himalayas.

Part 4.—On Indian fossil vertebrates. On the geology of the North-west Himalayas. On blown-sand rock sculpture. Re-discovery of Nummulites in Zanskar. On some mica traps from Barakar and Raniganj.

Vol. XXII, 1889.

Part 1.—Annual report for 1888. The Dharwar System, the chief auriferous rock-series in South India. (Second notice.) On the Wajra Karur diamonds, and on M. Chaper's alleged discovery of diamonds in pegmatite near that place. On the generic position of the so-called Plesiosaurus Indicus. On flexible sandstone or Itacolumite, with special reference to its nature and mode of occurrence in India, and the cause of its flexibility. On Siwalik and Narbada Chelonia.

Part 2.—Note on Indian Steatite. Distorted pebbles in the Siwalik conglomerate. The 'Carboniferous Glacial Period.' Notes on Dr. W. Waagen's 'Carboniferous Glacial Period.' On the oil-fields of Twingoung and Beme, Burma. The gypsum of the Nehal Nadi, Kumaun. On some of the materials for pottery obtainable in the neighbourhood of Jabalpur and of Umaria.

Part 3.—Abstract report on the coal outcrops in the Sharigh Valley, Baluchistan. On the discovery of Trilobites by Dr. H. Warth in the Neobolus beds of the Salt-range. Geological notes. On the Cherra Poonjee coal-field, in the Khasia Hills. On a Cobaltiferous Matt from Nepál. The President of the Geological Society of London on the International Geological Congress of 1888. Tin-mining in Mergui district.

Part 4.—On the land-tortoises of the Siwaliks. On the pelvis of a ruminant from the Siwaliks. Recent assays from the Sambhar Salt-Lake in Rajputana. The Manganiferous Iron and Manganese Ores of Jabalpur. On some Palagonite-bearing raps of the Ráj-mahál hills and Deccan. On tin-smelting in the Malay Peninsula. Provisional index of the local distribution of important minerals, miscellaneous minerals, gemstones, and quarry stones in the Indian Empire. Part 1.

Vol. XXIII, 1890.

Part 1.—Annual report for 1889. On the Lakadong coal-fields, Jaintia Hills. On the Pectoral and pelvic girdles and skull of the Indian Dicynodonts. On certain vertebrate remains from the Nagpur district (with description of a fish-skull). Crystalline and metamorphic rocks of the Lower Himalayas, Garhwál and Kumaun, Section IV. On the bivalves of the Olive-group, Salt-range. On the mud-banks of the Travancore coast.

Part 2.—On the most favourable sites for Petroleum explorations in the Harnai district, Baluchistan. The Sapphire Mines of Kashmir. The supposed Matrix of the Diamond at Wajra Karur, Madras. The Sonapet Gold-field. Field Notes from the Shan Hills, (Upper Burma). A description of some new species of Syringosphæridæ, with remarks upon their structures, &c.

Part 3.—On the Geology and Economic Resources of the Country adjoining the Sind-Pishin Railway between Sharigh and Spintangi, and of the country between it and Khattan (with a map). Report of a Journey through India in the winter of 1888-89, by Dr. Johannes Walther, translated from the German, by R. Bruce Foote. On the Coal-fields of Lairungao, Maosandram, and Mao-be-lar-kar, in the Khasi Hills (with 3 plans). Further Note on Indian Steatite. Provisional Index of the Local Distribution of Important Minerals, Miscellaneous Minerals, Gem Stones, and Quarry Stones in the Indian Empire (continued from p. 286, Vol. XXII).

Part 4.—Geological sketch of Naini Tal; with some remarks on the natural conditions governing mountain slopes (with a map and plate). Notes on some Fossil Indian Bird Bones. The Darjiling Coal between the Lisu and the Ramthi rivers, explored during season 1890-91 (with a map). The Basic Eruptive Rocks of the Kadapah Area. The Deep Boring at Lucknow. Preliminary Note on the Coal Seam of the Dore Ravine, Hazara (with two plates).

Vol. XXIV, 1891.

Part 1.—Annual report for 1890. On the Geology of the Salt-range of the Punjab, with a re-considered theory of the Origin and Age of the Salt-Marl (with five plates). On veins of Graphite in decomposed Gneiss (Laterite) in Ceylon. Extracts from the Journal of a trip to the Glaciers of the Kabru, Pandim, &c. The Salts of the Sambhar Lake in Rajputana, and of the Saline efflorescence called 'Reh' from Aligarh in the North-Western Provinces. Analysis of Dolomite from the Salt-range, Punjab.

Part 2.—Preliminary Report on the Oil locality near Moghal Kot, in the Sheráni country, Suleiman Hills. On Mineral Oil from the Suleiman Hills. Note on the Geology of the Lushai Hills. Report on the Coal-fields in the Northern Shan States. Note on the reported Namsèka Ruby-mine in the Mainglôn State. Note on the Tourmaline (Schorle) Mines in the Mainglôn State. Note on a Salt-spring near Bawgyo, Thibaw State.

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Part 4.—On a Collection of Mammalian Bones from Mongolia. Further note on the Darjiling Coal Exploration. Notes on the Geology and Mineral Resources of Sikkim (with a map). Chemical and Physical notes on rocks from the Salt-range, Punjab (with two plates).

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Part 1.—Annual report for 1891. Report *on the* Geology *of* Thal Chotiáli *and part of the* Mari country (with a map and 5 plates). Petrological Notes *on the* Boulder-bed *of the* Salt-range, Punjáb, Sub-recent *and* Recent Deposits *of the valley plains of* Quetta, Pishin, and the Dasht-i-Bedaolat; *with appendices on the* Chamans *of* Quetta; *and the* Artesian water-supply *of* Quetta *and* Pishin (with one plate).

Part 2.—Geology *of the* Saféd Kóh (with 2 plates of sections). Report *on a* Survey *of the* Jherria Coal-field (with a map and 3 section plates) (*out of print*).

Part 3.—*Note on the* Locality *of* Indian Tscheffkinite. Geological Sketch *of the* country north of Bhamo. Preliminary Report *on the* economic resources *of the* Amber *and* Jade mines area *in* Upper Burma. Preliminary Report *on the* Iron-Ores *and* Iron-Industries *of the* Salem District. *On the* Occurrence *of* Riebeckite *in* India. Coal *on the* Great Tenasserim River, Mergui District, Lower Burma.

Part 4.—Report *on the* Oil Springs *at* Moghal Kot *in the* Shirani Hills (with 2 plates). Second Note *on* Mineral Oil *from the* Suleiman Hills. *On a* New Fossil, Amber-like Resin *occurring in* Burma. Preliminary notice *on the* Triassic Deposits *of the* Salt-range.

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Part 1.—Annual report for 1892. Notes *on the* Central Himalayas (with map and plate). Note *on the occurrence of* Jadeite *in* Upper Burma (with a map). On *the* occurrence *of* Burmite, *a new* Fossil Resin *from* Upper Burma. Report *on the* Prospecting Operations, Mergui District, 1891-92.

Part 2.—Notes *on the* earthquake *in* Baluchistán *on the* 20th December 1892 (with 2 plates). Further Note *on* Burmite, *a new amber-like fossil resin from* Upper Burma. Note *on the* Alluvial deposits *and* Subterranean water-supply *of* Rangoon (with a map).

Part 3.—On the Geology *of the* Sherani Hills (with maps and plates). On Carboniferous Fossils *from* Tenasserim (with 1 plate). *On* a deep Boring *at* Chandernagore. Note *on* Granite *in the districts of* Tavoy *and* Mergui (with a plate).

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Part 1.—Annual report for 1894. *Cretaceous Formation of Pondicherry*. *Some* early allusions *to* Barren Island; *with a few remarks thereon*. Bibliography *of* Barren Island *and* Narcondam, *from* 1884 *to* 1894; *with some remarks*.

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Part 1.—Prefatory Notice. On a deposit of copper ore near Komai, Darjeeling District. Note on the Zewan beds in the Vihi District, Kashmir. Report on the coal deposits of Isa Khel, Mianwali District, Punjab. Report on the Um-Rileng Coal-beds, Assam. Note on a sapphirine-bearing rock from Vizagapatam District. Miscellaneous Notes. Assays.

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Vol. XXXII, 1905.

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