

A SURVEY OF NON-FERROUS MINERALS AND INDUSTRY IN INDIA

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Abstract

In this short paper, a survey of non-ferrous mineral production and reserves of India is attempted, emphasizing the present deficiencies and surplus capacities in the general context of indigenous requirements and export overseas. Attention is drawn to the possibilities of substituting available indigenous materials for those in short supply and to making the most of the metals of which resources are abundant. The general policy enumerated in the Five Year Plan of putting home use before export and of exporting semi-manufactured or fully manufactured products rather than untreated ores is endorsed. Each of the important metalliferous minerals is dealt with in turn in respect of reserves, production and the existing non-ferrous industry or that which could readily be established. Specific lines along which advances are most probable are indicated for aluminium, copper, lead and zinc.

Introduction

METALS and alloys form the basic raw materials for the development of light and heavy engineering industries in any country. The measure of their growth is a yardstick of the country's general progress in terms of modern civilization. The metallurgical industry is broadly classified in two broad groups, viz. ferrous and non-ferrous. The latter includes various non-ferrous metals and their alloys, as also the minor and rare earth metals. Of all numerous non-ferrous metals, the eight most important are lead, copper, zinc, aluminium, tin, manganese, nickel and antimony, to which is now added the wonder metal — titanium. These metals supplemented by their alloys form the chief backbone of non-ferrous metal trade and industry.

Indian Resources of Non-ferrous Mineral Wealth

Non-ferrous ores have been known to exist from ancient times in India and sporadically worked. With the notable exception of bauxite, manganese, magnesite and ilmenite, known reserves of non-ferrous metallic ores in India are meagre. For non-ferrous metal industry in its present diminutive form, estimated reserves of some minerals may be viewed without alarm. Copper is an instance of it. But considered in the larger context of population, area and consumption of non-ferrous minerals in western countries, these resources are meagre. The acute realization for intensive development of known mineral resources and exploration for pastures new is of relatively recent origin. Statutory provision — the Mines and Minerals (Regulation and Development) Act — was made only in 1948. The Geological Survey of India has been striving hard to determine the extent of known mineral reserves and venturing to discover new deposits. Five field sections of the Department undertook 211 special surveys in 1948 and over 245 special surveys in various States during 1951. Although discovery of new deposits and full development of known reserves and their industrial exploitation will take time, the efforts have yielded useful data. In its present form, however, development is essentially the result of the last war. The peril then posed of shortage of metals gave an impetus to indigenous attempts to develop the industry and the war-time expansion continued along modern lines after the war. The data on non-ferrous mineral

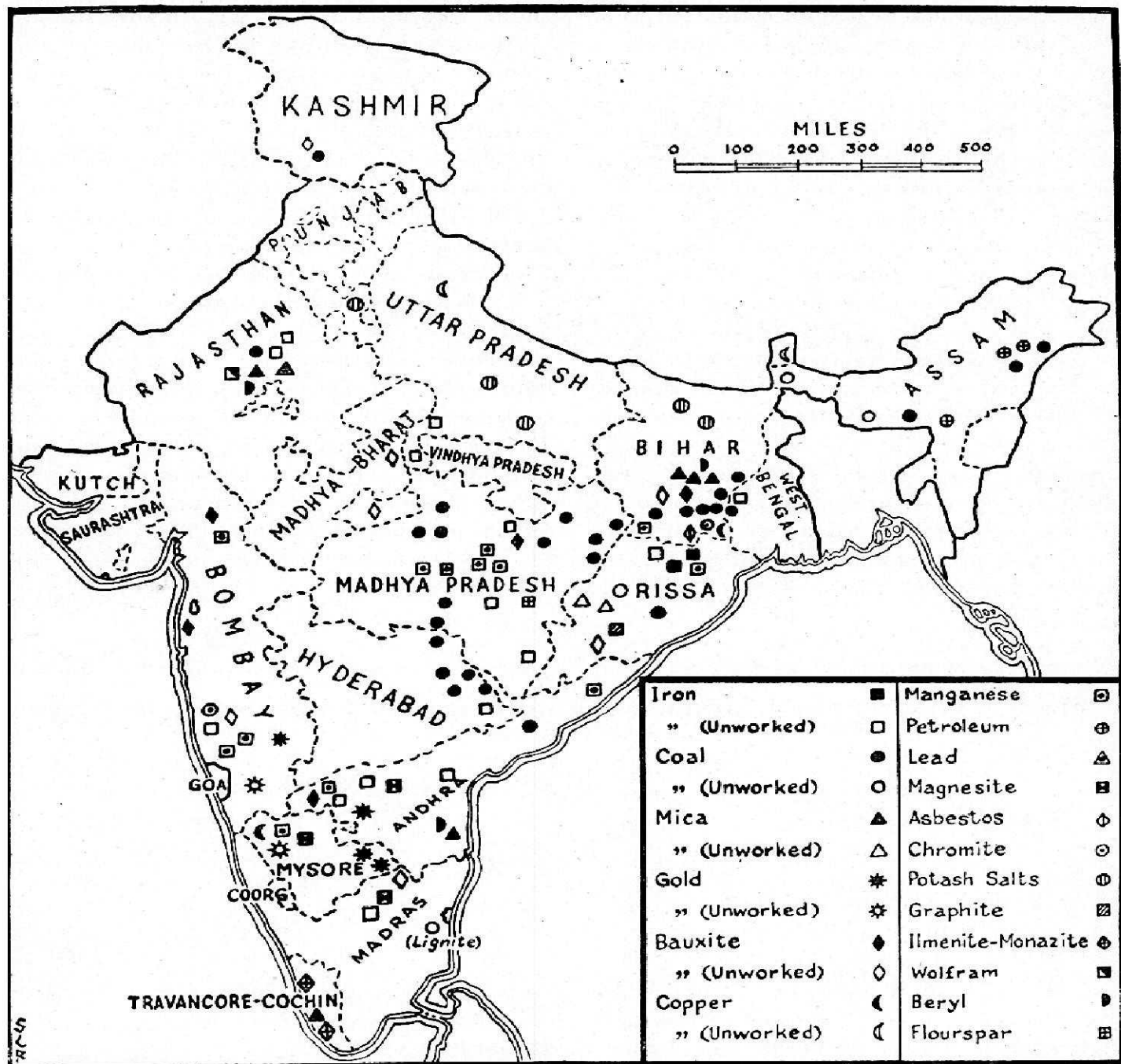


FIG. 1 — MAP SHOWING THE MINERALS OF INDIA

reserves had to be re-oriented with the partition of the country in 1947, resulting in the loss of some very important mineral deposits such as of chromite occurring in the Zhob Valley of Baluchistan. The present position with respect to the occurrence of minerals in India is depicted in the accompanying map. In broad outline, the reserves of coal esti-

mated to a depth of 1000 ft. are of the order of 25,000 million tons in workable seams. Leaving alone our classic reserves of quality iron ores, the reserves of high-grade manganese ores according to the most up-to-date estimates are figured at 40-60 million tons and probably two to three times that quantity of low-grade manganese ores. Over a hundred

million tons of magnesite are estimated to lie in South India. Of bauxite, ilmenite and mica the country has enviable reserves. Among the notable deficiencies are sulphur, ores of copper, zinc, tin, lead, mercury, nickel, tungsten, molybdenum and a few others. In non-metallic minerals, India appears self-sufficient in relation to her present demands, such as of clays, glass sands, abrasives, mineral pigments, refractories and so on.

Until recently, Indian non-ferrous minerals were mostly won for export purposes, but this policy is now being reoriented towards conservation of resources and early development of home industries exploiting our non-ferrous minerals, without at the same time wholly closing the door to the export of minerals which are of considerable importance to the national exchequer, such as manganese. The setting up of a chain of national laboratories, expansion of the Geological Survey of

India, establishment of the Indian Bureau of Mines, are examples followed for the implementation of the above policy. Non-ferrous mineral production in India for the years 1950 and 1951 is given in Table 1. The break-up figures for the mineral production in 1951 are given in Table 2. Table 3 details the figures for production, imports and total consumption of principal minerals and metals in India during 1950. During 1952 were recorded the highest production figures for coal, manganese ore, gold and gypsum. Compared to the production figures for 1947, the increase in the output of coal was about 20 per cent, manganese over 200 per cent, gypsum over 700 per cent and gold over 47 per cent. The total pit-mouth value of minerals produced in India during 1952 is estimated at Rs. 111 crores as against Rs. 107 crores for 1951, excluding petroleum in both cases.

TABLE 1—NON-FERROUS MINERAL PRODUCTION IN INDIA FOR THE YEARS 1950 AND 1951

(In round figures)

MINERAL	1950			1951		
	Value in thousands of rupees	Weight in thousands of tons	Average rupees per ton	Value in thousands of rupees	Weight in thousands of tons	Average rupees per ton
Asbestos	180	0.2	900	240	0.5	480
Bauxite	650	50	13	737	67	11
Chromite	560	14	40	918	17	54
Coal	480000	32000	15	516000	34400	15
Copper ore	12240	360	34	18500	370	50
Gold (metal)	59200	200	296	67800	226	300
		oz.	oz.		oz.	oz.
Graphite	80	1	80	240	2	120
Gypsum	1400	200	7	1224	204	6
Ilmenite	3185	213	15	4256	224	19
Kyanite	3240	27	120	5880	42	140
Magnesite	1155	55	21	1872	117	16
Manganese ore	86400	900	96	178020	1290	138
Mica	89600	320	280	137200	490	280
TOTAL	778250			987320		

TABLE 2 — MINERAL PRODUCTION OF INDIA FOR THE YEAR 1951

MINERAL	TOTAL VALUE, Thou- sands Rs.	TOTAL VALUE, Thou- sands Rs.	ASSAM	WEST BENGAL	BIHAR	BOMBAY	HYDE- RABAD	MADHYA BHARAT	MADHYA PRADESH	MADRAS	ORISSA	RAJA- STHAN	TRAVAN- CORE- COCHIN	OTHER STATES
Asbestos	240	0.5	—	—	48.0	—	—	4.0	—	28.0	20.0	—	—	—
Bauxite	737	67	—	—	29.9	—	—	—	38.7	1.5	—	—	—	—
Chromite	918	17	—	—	21.2	—	—	—	—	25.8	43.6	—	—	—
Coal	516000	34400	1.3	27.8	53.5	—	8.7	—	9.3	—	—	0.8	—	2.2
Copper ore	18500	370	—	—	100.0	—	4.0	—	—	—	—	—	—	—
Gold (metal)	67800	226 oz.	—	—	—	—	—	—	—	—	—	—	—	—
Graphite	240	2	—	—	—	—	—	—	—	—	96.0	—	—	—
Gypsum	1224	204	—	—	—	—	—	—	18.5	—	—	—	—	—
Ilmenite	4256	224	—	—	—	—	—	—	—	16.1	—	—	—	1.0
Kyanite	5880	42	—	—	92.5	—	—	—	—	—	—	—	—	1.3
Magnesite	1872	117	—	—	—	—	—	—	—	—	—	—	—	—
Manganese ore	178020	1290	—	—	3.7	—	—	1.2	54.2	96.5	3.5	—	—	—
Mica	137200	490 cwt.	—	—	—	—	—	—	—	12.8	1.0	—	—	—
Salt	60720	2640	—	—	—	—	—	—	—	Figures of States not available	—	—	—	—
Other minerals	54433	—	—	—	—	25.3	—	—	—	27.0	—	16.5	2.5	27.3

Bauxite

Deposits in India of bauxite are widely scattered, but occur mainly in the Ranchi and Palamau districts of Bihar, Belgaum, Khairā and Thana districts of Bombay, the State of Kolhapur, Jubbulpore, Balaghat, Mandea and Bilaspur districts of Madhya Pradesh, the States of Rewa and Bhopal, Raisi and Poonch districts of Kashmir, Salem in Madras and the Bababudan Hills of Mysore. Total bauxite reserves are estimated at 250 million tons, of which 35 million tons are said to be of high grade.

There are in India today two principal units producing aluminium, the Indian Aluminium Company and the Aluminium Corporation of India. The equipment and machinery of Indian Aluminium Company are mostly of British and Canadian manufacture. The Company has its bauxite mines at Lohardaga in Bihar; ore-refining plant at Muri in Bihar; aluminium reduction works at Alwaye in Travancore; and rolling mills at Belur near Calcutta. The first aluminium ingot was produced in March 1943. The mines are capable of producing 4000 tons of bauxite per month. Their ore-refining plant can produce about 10,000 tons of alumina per year. With suitable additions the plant can be made to produce 40,000 tons of alumina per annum. The reduction works at Alwaye are producing about 2500 tons of aluminium per year. If adequate electric power is made available, they can produce 5000 tons of aluminium per year. Their rolling mills at Belur are turning out aluminium sheets and circles at the rate of 3500 tons a year. The rolling plant is capable of producing 5000 tons per year.

The Aluminium Corporation of India has its mines in Lohardaga (Bihar). Its equipment includes an ore-refining plant, reduction works, power house and a rolling mill — all located in Jaykaynagar near Asansol. Bulk of the machinery was supplied by the Czechoslovakian firm of Skodas. The first aluminium ingot was produced in July 1944.

TABLE 3 — THE PRODUCTION AND CONSUMPTION OF PRINCIPAL MINERALS AND METALS IN INDIA DURING 1950

MINERAL OF METAL	UNIT	PRODUCTION	RETAINED IMPORTS	EXPORT OF DOMESTIC PRODUCTION	AVAILABLE FOR CONSUMPTION
<i>Minerals and metals which may be said to be adequate for India's own requirements</i>					
Aluminium ore (bauxite)	Tons	64399	—	344	64055
Coal	"	32307481	1425	903145	31405764
Coal-tar and pitch	"	84844	386	—	85230
Felspar	"	1772	—	—	1772
Ilmenite	"	212663	—	—	—
Iron ore	"	2971276	207	35323	2916161
Iron (pig)	"	1645700	322	30402	1615620
Kyanite	"	35488	—	31496	2992
Sillimanite	"	1475	—	—	36393
Magnesite	"	52859	—	805221	74708
Mica	Cwt.	162447	5200	325342	—
Manganese ore	Tons	882929	—	805221	74708
Monazite (g.)	—	—	—	—	—
Steatite	Tons	25485	—	4188	21297

Minerals and metals which are inadequate for India's requirements

Aluminium (unwrought)	Tons	3594	{ 1836 (U.W.) 5217 (W.) }	—	10647
Asbestos	"	208	{ 10782 (raw) 6213 (mfd.) }	—	17203
Borax	Cwt.	(a)	{ 45676 44 (U.W.) }	—	45676
Brass, bronze, etc., (unwrought)	Tons	8042	{ 14511 (W.) }	399	22207
Copper (unwrought)	"	6614	34035 (U.W.)	7474	48391
Diamond	"	2769	—	—	—
Graphite	"	1586	881	—	2467
Lead (conc.)	"	1976	31	—	2007
Lead (pig)	"	629	15445	410-450	15624
Phosphate (apatite)	"	3025	53445	—	56470
Quicksilver	Lb.	—	2412291	—	2412291
Silver	Oz.	15676	111605	260	125121
Sulphur	Cwt.	—	1129756	—	1129756
Tin	"	—	95466	—	95466
Vermiculite	"	52	—	—	52
Wolfram	"	3	—	—	3
Zinc	"	—	33400	—	33400

(a) Known to be produced but production figures not available.

Total production of aluminium in India amounted to 3236 tons in 1946, 3215 tons in 1947 and 3362 tons in 1948. The following figures show the production of aluminium in 1949 and 1950 in India:

	1949	1950
	Tons	Tons
Indian Aluminium Company	2336	2313
Aluminium Corporation of India	1154	1278
	<hr/> 3490	<hr/> 3591

Progress in the rolling and fabricating sections was stimulated by the cessation of imports during the last war. As early as in June 1946, the Tariff Board reported that 'the Indian aluminium rolling industry has sufficiently developed to roll about 10,000 tons of ingot' and 'there is a large number of plants scattered all over the country and engaged mainly in the manufacture of domestic utensils'. Despite difficulties of importing equipment, rolling and fabricating factories' production continues to increase. The first factory to be set up in India for the manufacture of steel-reinforced aluminium cables has been established (Aluminium Industries Ltd., Kundara) in Travancore-Cochin State. A factory for the production of aluminium powder has been set up in Bombay. Steps have been taken to improve existing facilities for the manufacture of aluminium foil to meet the demands of the cigarette industry and for use as milk strips and capsule foils.

For the production of one ton of aluminium approximately 13 tons of raw material are required, made up as follows: bauxite, 5 tons; coal, 6 tons; lime, 0.5 ton; petroleum coke, 5 tons; pitch, 0.25 ton; soda ash and caustic soda, 0.3 ton; cryolite, 0.1 ton; aluminium fluorides, 0.05 ton; fuel oil, 0.3 ton; filter cloth, 10 yards, and hard coke, 0.5 ton. Supplies of coal and coke are satis-

factory. Regular lime supplies come from deposits in Madhya Pradesh and Bihar. The only source of petroleum coke in India is Digboi in Assam. Pitch is obtained from the collieries and there is no difficulty in getting supplies. Cryolite and aluminium fluoride have to be imported. Production of soda ash and caustic soda in India is limited. The aluminium industry has, therefore, to import part of its raw material requirements. Against the production of 3700 tons of aluminium in 1951, at the end of 1955-56, according to the Five Year Plan, the annual indigenous production should exceed 12,000 tons. It does not appear to be too ambitious a figure. Present world production capacity of aluminium is estimated at about 2 million tons. Germany and the U.S.A. were the largest producers of aluminium before World War II. German production was at that period the bigger of the two. Canada has since come into prominence. She will soon be producing over 400,000 tons of aluminium a year. Ingot imports into India in recent years have been mostly from Canada. In view of the increasing number of uses to which the metal is now being put, our present demand is estimated at about 16,000 tons per year (including ingots, sheets and circles). Of this nearly 10,000 tons are required by the utensil-manufacturing section of the industry. Other sections are A.C.S.R. cables (2500 tons), aluminium foil (700 tons), aluminium powder (300 tons), aluminium castings (100 tons), and other industrial uses (2400 tons). The current consumption trends appear to have somewhat declined, but are expected to rise as the implementation of the Five Year Plan progresses with increased industrialization. Electrical cable demands for hydro-electric power transmission are likely to register considerable increase as the different hydro-electric projects are completed. Export of alumina to Australia will be expected in the very near future when the new aluminium reduction plant at Bell-Bay in Tasmania starts operations.

Antimony

There are small deposits of antimony in Lahaul (Kangra district, East Punjab) and at Shagor in Chitral State. There have been reports of deposits of antimony sulphide ore near Raipur in Madhya Pradesh. Investigations in that area are actively underway by the Geological Survey of India. Production of antimony in India is confined to one plant — the Star Metal Refinery, Bombay, which has its refinery at Vikhroly. Installed capacity is about 900 tons per annum, which, if fully utilized, could almost wholly meet the country's antimony requirements. Production commenced in 1941. Output rose from 56 tons in that year to 235 tons in 1947. Till 1947, the Company's raw material, i.e. antimony sulphide ore, came from its mines in Chitral State, N.W.F.P. Since partition of the country, ore supplies from Chitral ceased. These supplies are now imported chiefly from Bolivia. Production in 1948 amounted to 330 tons. In 1949, demand for the indigenous product fell owing to large imports of antimony and production was only 100 tons. Present production is estimated at about 600 tons a year.

Copper

Copper is mined and smelted in Singhbhum, Bihar. Although copper ore deposits have been recorded in Assam, Bengal, parts of Bihar, Madhya Pradesh, Garhwal, Almora, Kashmir and Jammu, Madras, Mysore, Rajputana and Sikkim, their economic working has not yet been established. The Indian Copper Corporation, with mines at Mosabani and works at Moubhandar, is the only copper smelter in India. The ore is crushed at Mosabani and sent by aerial rope-way, some 6½ miles long, to the concentration plant at Moubhandar. The Corporation was established in 1924 and copper production began in 1928. In 1930, a hot-rolling mill was set up for the production of brass sheets for utensil manufacture and in 1950 a cold-

rolling mill was installed, which enabled the Corporation to produce cold-finished sheets.

Production of copper at the Copper Corporation during the last few years has varied from 6500 to 7000 tons of blister copper a year extracted from the treatment of about 350,000 tons of chalcopyrite Mosabani copper ores. Of their present production, about 6000 tons are used by the Corporation to make brass and copper sheets. The most important raw materials required are coal for power generation and zinc. Coal supply is said to be satisfactory. Zinc is imported. The Corporation employs about 7000 persons.

In the field of semi-manufacture also there has been progress. Demand for brass and copper wire, sheet and strip, rods, bars and tubes was heavy during the war including extruded sections. A number of companies undertook this new type of work including the modern plant of National Pipes and Tubes Limited in Calcutta. Following production figures are given for copper wire:

INDUSTRY	INSTALLED CAPACITY, Tons	YEAR	PHYSICAL OUTPUT, Tons
Bare copper conductors	24,000	1946	7856
		1947	—
		1948	5880
		1949	5725
Winding wires	396	1946	211
		1947	—
		1948	330
		1949	340
	Yards		Yards
Rubber insulat- ed cables and flexibles	50,40,000	1946	22,609,723
		1947	—
		1948	22,000,000
		1949	19,356,274

More recent figures relating to these items are not too far apart.

Brass and copper wires made in India are said to be of reasonably good standard; brass sheets are comparable in quality with the imported product. Important producers

of copper non-ferrous alloys for different purposes are the group of Binani and Kamani Industries, Annapurna Metal Works, National Pipes and Tubes Limited, etc.

Pre-war consumption of copper in all forms was estimated at 35,000 and 40,000 tons a year. Present consumption is put at well over 40,000 tons a year. *Per capita* it is only 4 oz. In the U.S.A. and U.K. it is 18.25 lb. and 16 lb. respectively. India produces only about 15 per cent of her current copper requirements. The balance has to be imported at a great cost. It seems doubtful if India will ever be self-sufficient in copper. Consumption is certain to increase with further industrialization and as implementation of Five Year Plan progresses into its final stages.

Lead

Lead deposits now being exploited in India are located at Zawar in Udaipur State and at the Banjari mines in Jaipur State in Rajasthan. These are now under lease to the Metal Corporation of India Limited. Other deposits are known to exist in Rajasthan, Bihar and Madras, and are being investigated. Detailed prospecting for lead in the area round Pinki, Tehri-Garhwal, has been part of the field programme of the Geological Survey of India in recent years. It is not yet fully established if any of these deposits is economically workable. Manufacture of pure lead ingots began in 1942-43 in the works of the Metal Corporation of India. The Corporation has its mines in Jaipur and Udaipur States in Rajasthan and its lead smelter at Katrasgarh in the coal-fields near Dhanbad. Starting with an initial content of 6-8 per cent of lead in the ore, it is upgraded to 60-65 per cent lead through suitable mineral beneficiation technique. Installed refining capacity is estimated at 7000 tons per annum. In 1947, 190 tons of lead were produced, 625 tons in 1948 and 593 tons in 1949. Present production is estimated at about 1250 tons per annum. New

installations underway promise further increase in output. It is learnt that the Government of India have given financial assistance for development of lead mining and have set up a committee to examine the whole problem and make suitable recommendations. Hopeful results may, therefore, be expected.

During the last few years there has been considerable progress in the production of lead pipes and sheets. Lead pipes of Indian manufacture are extensively used in household water fittings and in the construction of chemical plant. The tea industry buys large quantities of lead sheet for lining tea-chests. Lately there has been a move — lead being in short supply — to use aluminium instead of lead for lining tea-chests. Present consumption of lead (all sorts) in India is estimated at about 17,000 tons. The gap between demand and production is about 15,750 tons which has to be bridged by imports. The Hindusthan Cable Factory which is being set up by the Government of India at Chittaranjan will use antimonial lead for sheathing telephone cables containing 0.08-0.90 per cent antimony.

Nickel and Cobalt

There is no mining of nickel in India. No economically workable deposits are yet known. The nickel in the Singhbhum copper ores is not considered 'profitably recoverable'. There have been reports of workable deposits in Nepal, but nothing definite is known so far. During 1950, imports included about 981 tons of alloy nickel scrap and about 196 tons as pellets, coin blanks, etc. Likewise India has no workable deposits of cobalt. Traces of cobalt occur with the copper ores of Khetri (Rajasthan) and the manganese ores of Kalahandi (Orissa).

Manganese

India is second among the manganese-producing countries of the world — the U.S.S.R.

being the first. There have lately been attempts, sponsored by the U.S.A., to increase output in South Africa. Indian manganese ore is of high quality. Production in India has been steadily on the increase. Table below summarizes the progress:

Undivided India

Year	Tons
1945	210,583
1946	256,916
1947	451,034

Indian Union

1948	525,876
1949	645,825

Figures for 1950 and 1951 have exceeded the million ton mark. During 1952, 1.4 million tons of manganese ore were produced.

Deposits now being worked are in Singhbhum (Bihar); Panchmahal (Bombay); Balaghat, Bhandara, Chhindwara, Nagpur (Madhya Pradesh); Indore (Madhya Bharat); Vizagapatam, Sundur (Madras); Shimoga (Mysore State); Bonai, Keonjhar, Koraput (Orissa); Patna State and Banskwara (Rajasthan). Ore supplies are abundant. Madhya Pradesh produces more than 60-70 per cent of the ore mined in India. Investigation of manganese ore deposits in Bombay, Kalahandi district, Bonai, Gangpur, Mayurbhanj (Orissa) and Balaghat district formed part of the programme of the Geological Survey of India and new and extensive deposits in Balaghat (Madhya Pradesh), Kalahandi and Bihar have been discovered.

Present methods of mining are wasteful and the need for improvement therein is a national necessity. The industry is being assisted by the State in several ways, the more important being supply of explosives, steel, cement, petrol; allotment of wagons; facilities for importing mining equipment; and the services of experts when required. In contrast to most other non-ferrous minerals, manganese is an earner of valuable foreign exchange for India. Among the more important importing countries are the

U.S.A., Britain, Canada, France, Norway and Belgium.

Exports during the last few years have been:

Year	Total Output	Hard Currency Countries
	Tons	Tons
1948	363,482	221,496
1949	613,907	411,642
1950	728,280	561,196

Latest figures indicate the export of over a million tons of manganese ore to foreign markets per annum.

There have been at times protests against the depletion of indigenous resources by increased ore exports of this mineral — vital in times of peace and war. Production in India of exportable grades of standard ferro-manganese in place of raw unprocessed manganese ores, through thermal beneficiation and electric smelting methods, is of the greatest national importance. Likewise, the production of electrolytic manganese of high purity and manganese dioxide for chemical and dry battery industries must be given the importance it so vitally deserves.

A small quantity of manganese ore is smelted in India for the production in iron blast furnace of ferro-manganese. Tatas produce about 12,000-15,000 tons of blast furnace ferro-manganese a year for the manufacture of 'commercial steels'. Likewise, Steel Corporation of Bengal produce about 5000 tons of blast furnace ferro-manganese. About 2500 tons of this grade of ferro-manganese is made by other smaller units of steel production in the country. Electric ferro-manganese required for the manufacture of 'quality alloy steels' has to be imported. The dry battery industry which uses indigenous manganese is now expanding fast.

Tin

There is no commercial mining of tin in India. There have been reports of deposits in the Ranchi and Hazaribagh districts of Bihar. Further investigations have revealed

the existence of a stanniferous mineralized belt from village Jonha (near Ranchi), economic importance of which is being now assessed.

In 1940, there were 36 kerosene tinning and packing factories in India. By 1944, the number had increased to 45. Cessation of tin supplies from Burma and Malaya during the war reduced the number to 7 in 1946. By 1948, the number had again gone up to 25 employing in all about 6692 persons. Before the war imports of tin averaged over 2500 tons a year. During the war, supplies were controlled by the International Tin Control Board and India received her quota (2000 tons per annum) through the Ministry of Supply in the U.K. After the war, although State trading in all other non-ferrous metals ceased, the Government of India decided, in view of the continuing shortage of tin supplies, to continue State trading in tin. World supply position improved towards the end of 1949 and the Government of India decided at the end of 1949 to give up State trading in tin as well. During 1950, tin ingots came mostly from Canada, Hongkong, Malaya and Britain; tin — other sorts — from Holland and Britain and tin-lead alloy manufacturers in the U.S.A. At the outbreak of war in Korea imports again became tight, but the situation is now much better. Present consumption of virgin tin is estimated at over 5500 tons a year and of tin plate at about 120,000 tons a year. Production of secondary tin is almost negligible.

Zinc

Zinc ore deposits exist in Zawar in Rajasthan and are under lease to the Metal Corporation of India. There are believed to be deposits also in Kashmir. In December 1950 it was reported that a survey in Nepal had disclosed the existence of high quality zinc ore over an area of 20 square miles near Tiplin. Further investigation and exploitation are underway. Detailed geological mapping of the area around the Zawar

lead-zinc mines has been conducted by the Geological Survey of India. The zinc concentrate produced at Zawar averages 60 per cent zinc content starting with an initial 8-10 per cent of zinc in the ore. This zinc concentrate is exported for the extraction of the metal zinc. It is hoped that with State aid a zinc smelter in India should be set up in the not-too-distant a future. Present annual consumption in India is estimated at about 33,000 tons; and all of it has to be imported at a cost of over Rs. 400 lakhs a year. Vigorous geological investigations of newly reported occurrences of zinc ore in India seem highly essential.

Titanium

Titanium is more plentiful in the earth's crust than nickel, copper and zinc; its most important minerals are ilmenite and rutile. Typical analyses figures of Indian and foreign ilmenites are given in Table 4. Rutile, the other important titanium mineral, is derived from Travancore beach sands and also found in the Punjab, Kadavur in Trichinopoly district, Madras, Singhbhum and Dalbhum districts in Bihar. Titaniferous magnetite is found in Singhbhum and Mayurbhanj districts containing up to 28 per cent TiO_2 . The aluminous and ferruginous laterites of India contain high amounts of titanium. If aluminium is extracted from the aluminous laterites, the sludge obtained during refining should provide a potential source of titanium. The most important deposits of titanium minerals worked in India lie in Travancore, on the South-west Coast, in five stretches along the coast, viz. Nindakara (north of Quilon), Anjengo-Varkala (south of Quilon), Kovilam (south of Trivandrum), Muttam-Pudur (near Colachel) and Cape Comorin-Liparum (on the eastern coast of Tinnevely district). All these are under the control of the Atomic Energy Commission set up by the Government of India, who are anxious to encourage exploitation of the titanium contents. The chief minerals found

TABLE 4—CHEMICAL ANALYSES OF COMMERCIAL ILMENITES

LOCATION	CHEMICAL ANALYSIS PER CENT										
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	FeO	MnO	MgO	CaO	TiO ₂	Cr ₂ O ₃	V ₂ O ₅	P ₂ O ₅
Piney River, Va. U.S.A.	2.00	1.21	13.80	35.86	0.52	0.07	1.15	44.28	0.07	0.16	1.01
Roseland, Va., U.S.A.	4.58	0.55	1.54	37.86	0.70	2.35	0.59	51.41	nil	0.07	0.17
Quilon, Travancore, India	1.40	n.d.	24.80	9.70	n.d.	n.d.	n.d.	60.30	0.14	0.26	0.17
Manavalakurichi, Travancore, India	1.40	n.d.	15.50	26.00	n.d.	n.d.	n.d.	54.30	0.07	0.20	0.26
do	1.53	1.11	14.17	26.71	0.38	1.01	nil	53.56	0.09	0.03	0.20
Senegal, French West Africa	1.31	0.50	30.16	7.09	1.32	0.89	0.10	54.71	0.23	0.27	0.14
Norway	0.62	0.59	22.99	32.62	0.25	3.04	0.10	36.98	0.06	0.48	0.06
do	3.28	0.85	11.04	36.02	0.33	3.67	0.18	43.88	0.05	0.20	0.02
Malay States	1.00	—	3.77	38.52	3.15	0.27	nil	51.70	0.02	0.04	0.09

are quartz, monazite, rutile, zircon, garnet and ilmenite. The beach sands of Travancore are a mixture of mineral sands with a specific gravity varying from 2.3 of silica to 4.9 of monazite. These sands are derived through weathering of igneous rocks and in some regions these rocks have yielded laterites, while in the other, sandstones, as at Varkala. The mineralogical composition of the beach sand is:

	<i>Manavalakurichi</i>	<i>Nindakara</i>
	%	%
Ilmenite	75-80	80
Zircon	4-6	4-6
Sillimanite	2-4	3-5
Rutile	3-5	4-5
Garnet	3-5	less than 0.5
Silica	5-7	4-5
Monazite	about 1	0.5 to 1
Other minerals	less than 0.1	

As mined, the sands contain 50-70 per cent ilmenite. Several companies are working at Manavalakurichi and Koilhottam for the concentration of ilmenite, which is done by wet tabling to remove silica followed by dry tabling and magnetic separation. The material is first put through a 30-mesh vibrating screen to remove lime shells and other undesirable materials. It then passes through Whetherill electromagnetic separators. The magnetic concentrate goes to gravity concentrate tables to reduce garnet content. Beneficiation of rutile is difficult as it is feebly magnetic. Separation is effected by taking advantage of difference in electrical conductivities of the constituents. Zircon and monazite are obtained as by-products. As an indication of the scale of working at Travancore, it is noted that Indian Rare Earth's Limited, Alwaye, recently started, can process 1500 tons of monazite in a year and can produce 1000 tons of rare earth chlorides and 450 tons of carbonates therefrom.

We have recently been told of large titanium mineral beach sand deposits along the Bay of Bengal, with one area rich in rutile. These are under investigation by the Indian Bureau of Mines. Most recent reports indicate the possibility of uranium find in a mineral belt over 240 miles long running through West Bengal, Bihar and Orissa which is now under active investigation and scrutiny.

The production of titanium minerals in India during the past few years in tons is:

	<i>Ilmenite</i>	<i>Rutile</i>
1944	100,794	1646
1945	172,086	610
1946	185,023	258
1947	260,955	157
1948	229,416	127
1949	308,180	—
1950	212,663	36
1951	219,568	45
1952	224,895	147

It is difficult to give any quantitative idea of the reserves. This certainly amounts to millions of tons — roughly estimated at 200 million tons of ilmenite containing over 70 million tons of titanium.

A few months ago a notification was issued from the Ministry of Natural Resources and Scientific Research banning the export of ilmenite with any contents of monazite above 0.1 per cent.

Chromite

Chromite is an important strategic mineral, of which India has moderate supplies. The chief chromite deposits in India are situated in the Singhbhum district of Bihar, the Mysore and Hassan districts of the Mysore State, the Ratnagiri and Sawantwadi areas of Bombay, the Krishna and Salem districts of Madras, and Keonjhar district of Orissa. There are also deposits near Dras in Ladakh, Kashmir State, but these are prac-

tically inaccessible. Those in the Manipur State (Assam) and Andaman Islands will have to be investigated further before their economic importance can be ascertained.

No reliable estimates of reserves are available, but the following figures may be given as general indications:

	<i>Tons</i>	<i>Depth,</i> <i>ft.</i>
Mysore	135,000	—
Bombay	67,000	—
Orissa	200,000	20
Salem (Madras)	200,000	20
Krishna	Not known	

Before partition of the country the rate of chrome ore production exceeded 40,000 tons per annum with an export of bulk of the production. After the loss of Baluchistan supplies, the production of chrome ore in India has declined to about 20,000 tons per annum.

Magnesium

Of the chief commercial minerals of magnesium, magnesite, brucite and dolomite, India possesses considerable deposits of magnesite and dolomite, but no workable deposit of brucite. Important deposits of magnesite occur in the Salem district of Madras, in Southern Mysore and in the Almora district of U.P. The former two are now under active exploitation. In the Salem district, magnesite occurs as irregular thin veins from an inch to about a foot in thickness traversing ultra-basic rocks such as dunite. Most important deposits lie in the Chalk Hill areas near Salem town. Others worth mentioning in this area are Siranganur, Kundamalai, Sirappalli and Valaiyappatti. The Chalk Hill deposits are estimated at about 82 million tons up to a depth of 100 ft. Other Salem deposits contain reserves estimated at about 2 million tons. Several deposits occur at Dodkanya, Kada Kola and other places, a few miles south of Mysore city.

The following analysis is given of different Indian magnesites:

	SiO ₂	R ₂ O ₃	MgO	CaO	IGNITION Loss
	%	%	%	%	%
Chalk Hills	1.85	0.08	46.41	0.81	50.61
Sirappalli	0.72	0.12	47.10	0.56	51.51
Kundamalai	2.40	0.56	31.51	17.32	48.14
Valaiyappatti	0.78	0.26	41.26	5.34	52.05
Dodkanya (Mysore)	5.64	1.10	43.52	1.24	—

Minor deposits have been noticed near Fraserpet in Coorg, but no full data is yet available. A large deposit of sedimentary origin has come to light in the Almora district of U.P. about three years back. Dolomite and magnesium limestones are widely distributed throughout India and innumerable deposits occur in Madras, Andhra, Bihar, Madhya Pradesh, Rajasthan and Orissa. These reserves have not yet been accurately assessed, but are fully adequate for India's expanding needs.

Gold

The only deposits of value lie in Kolar Gold-fields in Mysore State which produce about 3 lakh oz. of gold a year. The veins are being worked at a depth of 7000-9000 ft. Smaller deposits of similar type in quartz veins are worked in neighbouring Madras and Hyderabad. Old Hatti mines near Raichur (Hyderabad) have yielded gold to the tune of 25 lakh of rupees. Mysore Government is now operating an abandoned gold mine near Bellara in Mysore. The discovery of a mineral belt containing gold running through West Bengal, Bihar and Orissa most recently announced has yet to be fully assessed.

Vanadium

The Singhbhum and Mayurbhanj titaniferous magnetites estimated at 9-10 million

tons contain about 14 per cent TiO₂, 1.26 per cent V₂O₅, 2.3 per cent SiO₂ and the rest iron. Little effort has yet been made to make full use of indigenous resources of vanadium. During the war, a plant at Rairangpur (Orissa) worked on the beneficiation of vanadium ores, but is now shut down since the end of war.

Beryllium

Beryl, the ore of beryllium, occurs in Rajputana, Madras, Kashmir and Bihar, in pigmatites associated with the granites. India's almost entire output was being exported at one time, but Atomic Energy Commission of the Government of India now handles its production and purchase.

Uranium, Cerium, Germanium, Thorium, Zirconium, etc.

India has large deposits of these minerals in the form of monazite Travancore beach sands which are estimated at over 2 million tons containing 8-9 per cent thorium. A factory for processing over 1500 tons a year of monazite beach sands has been recently set up by the Government of India at Alwaye (Travancore). Coal ash of some Indian coals is reported to contain germanium and work on its extraction therefrom is expected shortly to be taken in hand.

Tantalum and Niobium

Reported occurrences of tantalum and niobium minerals in India are many, but no assessment thereof has been accurately made yet. The Rare Mineral Section of the Atomic Energy Commission set up by the Government of India is pursuing exploitation of these two important minerals in India, meagre production of which was recorded from Bihar and Mewar (Rajasthan) some years back.

Graphite

Numerous small deposits of graphite are located in the Eastern Ghats, regions near Madras and Orissa. Some deposits occur in Travancore and Rajputana. The production at present is stated to be about 1000 tons a year.

Tungsten

There are no important wolfram deposits in India. Small deposits at Degana in Jodhpur (Rajasthan) have been sporadically worked during times of war crisis. Only other occurrence of importance is that of Chhendapathar in West Bengal. Only 10 tons of the mineral were raised during 1952 at Degana.

Having given a general résumé of non-ferrous mineral wealth of our country, some general facts clearly emerge which require rational and serious examination. It is proposed to discuss some general observations followed by some pointed references for development. Rational and objective examinations have to be made relating to the possibilities and great desirability of State exploring vigorously all avenues of trade relations with countries dominantly rich in such non-ferrous minerals in which India is substantially lacking. The mineral industry in general should suitably attempt exchange basis with foreign exporters bearing in mind that Indian mineral exports can be employed as bargaining counter to meet our deficiencies. It is at the same time most essential that indigenous available mineral resources should be put to the best national advantage and economy. Pursuing the first line of thought, it may be said that our surplus manganese ore, mica, iron ore and shellac could be offered in exchange for such non-ferrous metals as we badly need and import. Resources of non-ferrous metals are wasting assets and have to be sensibly exploited and husbanded. Suggestions in this line would lie in the greatest possible

attempts at scrap reclamation and recovery of secondary metals, substitution of scarce metals by those relatively more abundant in the country or those easily procurable, ban on wholesale mineral exports, stock-piling and lastly restriction on indiscriminate internal consumption. Utilization of scrap relieves pressure on primary metals and aids metal conservation. Production of virgin metals from home scraps is always vigorously attempted in foreign countries. In India, there are hardly any organized scrap utilization trade channels attempting scientific reclamation on commercial basis. Perhaps, there are scattered small units in the country engaged in the line; a notable example, however, is afforded by the production of blister copper and non-ferrous alloys through thermal refining of copper, brass and other non-ferrous metal scrap at the works of Indian Smelting and Refining Company in Bombay. The scrap-refining section of the industry has a valuable function to perform and needs to be efficiently organized along modern scientific and commercial lines.

Development work to find suitable substitutes for scarce metals in some of their most important uses requires serious examination. An important example is the use of aluminium in place of electrolytic purity copper for electric power transmission lines. The present price structure of metals is such that aluminium can economically replace copper for many electrical uses. In the background of availability of copper versus aluminium in India, this substitution requires serious consideration. The prices of copper and aluminium being not substantially far apart, the disparity in economy in the use of aluminium should not be regarded as a scarecrow. Even if, in relation to copper, thicker wires of aluminium have to be employed owing to the latter's lower conductivity compared to the former, the much lower density of aluminium should more than offset the handicap.

Notice has to be taken of stock-piling in foreign lands. Their objectives and methods

in this field need dispassionate examination and rational action both in times of peace and war, particularly if the latter is of 'cold' type.

Improvidence continues to dominate Indian uses of non-ferrous metals based on sentiment and ancient codes and customs. A considerable proportion of total available brass and copper is used in the manufacture of household utensils on a huge mass scale. This is a sheer waste of precious resources. Ordinary aluminium or plain types of straight chromium stainless steels could most advantageously be substituted for the purpose and this extravagant use of copper and brass restricted forthwith. All that is needed is a serious effort at educating the users of utensils bearing in mind the religious purity attached to the use of copper and brass vessels and utensils which needs to be shaken off. It is amazing that no serious heed has yet been taken of the use of high-priced imported electrolytic copper of electrical quality for the manufacture of ordinary household utensils simply because to the numerous manufacturers it still leaves a fair margin of profit between their cost and sale figures — that this problem calls for radical measures can hardly be over-emphasized.

The need for setting up effective distributional and allocation measures in the country should not merely spring into prominence during war emergencies but has to be put on an effective co-ordinated basis in times of peace as well. Whenever there is an international tension or war emergency, India's position relating to her requirements of non-ferrous metals becomes most unbalanced and precarious. It is, therefore, necessary to ensure that there should, at all times, be sufficient stock of metals in the country, with the industry or the State. It will, evidently, be more a State concern rather than that of the private sector of the industry, since the latter can ill afford to block up heavy financial investment in holding requisite stocks. A stock of deficient metals like copper, zinc,

aluminium, lead, tin, nickel and antimony, up to the extent of $1\frac{1}{2}$ to 2 years' normal consumption, to be kept by the State is not a proposition to be dismissed at the very first sight of it. The industry may as well, to her advantage, take its reasonable share in it by stocking a few months' supply to meet critical emergencies attendant upon present-day state of international politics and the 'cold' war which governs it. Financial considerations alone are not the only pivots on which hinge these long-range national issues for which suitable measures can be devised well in advance, such as public loans or the non-ferrous metal stocks treated as currency reserves like gold and silver. It has already been hinted that one of the means to build up such stocks would be to treat the export of commodities like jute, mica, coal, manganese and iron ores, etc., on barter basis in exchange for metals on which the indigenous non-ferrous industry depends and in which we substantially lack. India possesses surplus capacity in the manufacture of semis like brass and copper sheet and circles, lead pipes and tubes, lead sheets, white metal alloys such as solder, bearing metal, gunmetal, type metal, etc. These semis could be utilized for export markets principally for South-east Asia and East-Asian countries provided sufficient raw materials thereof are provided in the country.

Certain Specific Suggestions for Expanding Non-ferrous Metal Industry in India

1. The question of establishing an electrolytic copper refinery is a pressing one. India produces no electrolytic copper, all of which has to be imported. This refinery could use the low-grade copper scrap unfit for pyrometallurgical refining as also home blister copper supplemented by imports thereof. A 5000 tons a year electrolytic refinery capable of expanding to 10,000 tons a year is an economic proposition. A steady source of

low-grade scrap and raw materials has to be first organized to feed the refinery.

2. The present production of lead is about 1000-1250 tons a year, against the available smelting capacity of about 6000 tons a year. The Metal Corporation of India have recently set up an ore-dressing unit capable of milling 200 tons run-off-mine ore per day at their Zawar mines. They expect to produce about 500-700 tons of lead concentrate (50-60 per cent Pb) a month which, should their smelting capacity be utilized to the maximum, would ensure a supply of 350-400 tons of lead per month. They may also be in a position to smelt imported lead concentrate, if available.

3. With the advent of cheap hydro-electric power in India from the D.V.C., Hirakud Projects, etc., the indigenous production of aluminium could be stepped up fourfolds. The Indian Aluminium Co. are already investigating the possibility of installing a reduction plant at Hirakud dam site where cheap hydro-electric power should be available. This should eliminate the long-distance triangular transportation of alumina from Muri (Bihar) to Alwaye (Travancore) and aluminium ingots back from Travancore to Calcutta for rolling. These factors deserve serious consideration.

4. The Metal Corporation of India produce about 500-700 tons of zinc concentrate (50 per cent zinc) per month at Zawar. This zinc concentrate is exported for zinc smelting. The retort process of zinc smelting in preference to the production of electrolytic zinc could be worked out in India, as is being successfully accomplished in the U.S.A., U.K. and Belgium. Another line of attack would be the study of ammonia and ammonium carbonate leaching of low-grade zinc ores. In this connection some recent developments in Australia may be mentioned relating to their gold and copper resources at Mount Morgan in Queensland. Two important metallurgical processes are being developed which, it is hoped, will reduce production costs by obviating the smelting

and refining of blister copper. One process produces ammonium sulphide as a by-product, and this has extensive use as a fertilizer in Queensland for sugar industry. The Commonwealth Scientific and Industrial Research Organization is insisting the industry and has built a pilot plant. The object is to leach the copper out of the ore and produce copper by electrolysis. This should mean a saving of \$125 (£50) per ton on cost basis. The other process is to leach the copper with ammonia and oxygen at high pressure. By using a reducing agent, almost pure copper has been obtained. The Company's annual output is about 6000-7000 tons of copper and it is hoped that these processes will save them about \$750,000 (£300,000) annually. These modern metallurgical techniques in other countries are worth studying and following, with suitable modifications to suit the Indian raw material conditions.

5. Aluminium alloy sheets are not made in India at all. It is time the manufacture of strong alloy sheets even on a small scale is initiated in India to supplement the requirements of Hindusthan Aircraft Company at Bangalore for bus bodies or for aircraft purposes. The development of wrought and casting aluminium alloys is a field very much open to expansion and deserving of co-ordinated efforts. It was reported around 1951 that Government of Madhya Pradesh with the help of the Centre were seriously considering the setting up of an aluminium plant of 5000 tons per annum capacity at a site near Bilaspur, at Korba, in close proximity to bauxite resources. This proposal needs revival, if it is not already dropped.

6. Aluminium of 99.5 per cent purity for electrical purposes in the manufacture of A.C.S.R. cables has to be developed in India. The present demand for these wire-rods ($\frac{3}{8}$ - $\frac{1}{2}$ in. dia.) is roughly estimated at 5000 tons a year, practically all of which is imported from Canada and Europe. A development programme could be drawn up for

stepping up the manufacture of aluminium of this purity in India to feed the surplus rolling capacity of National Rolling Mills (Calcutta) as also making the fullest use of the wire-drawing and manufacturing capacity of Aluminium Industries Limited, Kundara, in the south for A.C.S.R. cables. It may be mentioned here that Indian bauxite is high in titania and refining technique has to be developed to reduce the titanium content to below 0.02 per cent for this grade of aluminium.

India, as a whole, cannot be said to be poor in mineral wealth. Most of her mineral resources, however, still require detailed examination and assessment. Under the impetus of the Five Year Plan of the Government of India, this process of assessment and investigation has already been stimulated and will gain further momentum with the advent of new metallurgical and engineering industries likely to be set up. It is only hoped that systematic and earnest thought will be focussed on the problems which face the Indian non-ferrous industry today, so as to fully exploit to national advantage the resources in which nature has been so generous to us and make most scientific and effective uses of those in which we have been less fortunate.

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Discussions

MR. P. P. BHATNAGAR (National Metallurgical Laboratory)

It is noticed that dross and other skimmings consisting mostly of metallic oxides are being exported — the dross being of tin and zinc besides other foundry skimmings. — Is anything being done in India to recover the metals? Would it not be desirable to leave the export of these and make maximum use of our scanty resources in the deficit minerals?

Dr. B. R. Nijhawan in his reply stated that the recovery of metallic values from dross and skimmings forms an important secondary non-ferrous industry in many countries and the importance of this secondary industry and its establishment on sound scientific lines in India has been stressed in the paper. I understand that during the war one or two firms were recovering tin from tin dross, but the position may not be so now. I would rather stress the importance of economic recovery of metallic values from these secondaries in preference to the export thereof both in times of peace and war.

DR. B. B. DEY (Director, Central Electro-Chemical Research Institute, Karaikudi)

Vanadium, a strategic material found only in small amounts in limited areas in the world, has been found in the Mayurbhanj State in Orissa not far from Tatanagar, occurring in certain titaniferous pegmatite ores. A firm named the Vanadium Corporation Limited had been started some time ago, and I remember to have received some ten years ago a sample of vanadium pentoxide made by this firm. It is not known if the work is being continued, but it is very desirable that our attention should be directed to this problem of extraction of vanadium and preparation of vanadium compounds from Indian minerals bearing this metal. Any information on this subject which the authors of this paper might give would be welcome.

Dr. B. R. Nijhawan in his reply stated that he has visited the vanadium extraction plant in Rairangpur near Jamshedpur, but has to state that the plant is now not in operation nor is it likely to be in operation in the foreseeable future. This firm worked economically during the last war, but soon after closed down due perhaps to easy availability of vanadium pentoxide through imports. The point of Dr. B. B. Dey is very important and worth consideration of the industrialists and the Government departments alike.