3.9 NONFERROUS MINERAL WEALTH OF INDIA

The mineral resources* of India are broadly classified into three categories as follows.

Adequate to Abundant

Minerals containing aluminium, beryllium, chromium, iron, manganese, magnesium, titanium, zirconium, thorium, and the rare earths.

Inadequate

Minerals containing copper, gold, carbon (graphite), lead, vanadium, zinc, nickel, cadmium, uranium, and tin.

Poor to So Far Not Known

Minerals containing antimony, bismuth, boron, cobalt, mercury, molybdenum, niobium and tantalum, phosphorus, selenium, sulphur, strontium, tellurium, silver, and tungsten.

The minerals in the first category, if properly exploited, can not only meet the domestic demand but can also yield a surplus for export. Although the minerals in the second category are insufficient to meet the growing domestic demand, they should be fully exploited. The resources in the third category are, at present, inadequate for commercial exploitation.

From the foregoing three categories, we see that although India is deficient in some of the common metals such as copper, zinc, lead, tin, cobalt, and nickel, its reserves of iron, manganese, magnesium, aluminium, and titanium are extensive. Further, India has abundant reserves of strategically important metals, namely, thorium, zirconium, and beryllium. We now discuss the mineral resources of individual elements.

ALUMINIUM

Bauxite is widely distributed in India, as is apparent from Table 3.9. The discovery of rich bauxite deposits has drastically changed the outlook for India's alumina industry. In the early nineteen sixties, the Geological Survey of India claimed that India had a potential reserve of about 250 million tons of bauxite which had an Al_2O_3 content of more than 50 per cent. This figure has

*The term 'resource' indicates the totality of a particular mineral occurrence in a region irrespective of the grade, the tonnage, or the economics of exploitation, whereas the term 'reserve' takes into account the grade and the degree of certainty with which the tonnage has been estimated for any particular cut-off grade.

Table 3.9 India's Potential Bauxite Reserves (after Das Gupta, 1979)

State/Union territory	Reserves (million tons)
Jammu and Kashmir	3.0
Bihar	45.0
Madhya Pradesh and Uttar Pradesh	105.0
Orissa and Andhra Pradesh	1614.0
Maharashtra, Karnataka, and Goa	146.0
Tamil Nadu	14.0
Kerala	13.0
Gujarat	100.0
Total	2040.0

now been conclusively established. It should be noted that the potential reserves are much more extensive. According to reliable sources, the East Coast of India has one of the world's largest deposits of bauxite. Since this deposit is rich in gibbsite and has a low content of silica and titania, it is ideal for the Bayer process (although it has a high content of iron oxides) for the extraction of alumina.

Currently, India has an installed capacity of 320,000 tons for aluminium products, which is adequate to meet the present demand. However, full capacity could not be achieved mainly due to power shortages. India's total production of aluminium in 1979 was estimated to be 208,000 tons against the consumption of 220,000 tons.

Das Gupta (1979) has predicted that after 1990, the whole of Europe, including the U.S.S.R., will have to rely largely on Africa and India for obtaining bauxite and alumina.

ANTIMONY

Commercially exploitable deposits of antimony have not been so far located in India, although small deposits of antimony ores have been found in Lahaul and Spiti (Himachal Pradesh). At present, the entire annual requirement, i.e., 500–700 tons, is being met by importing the metal, its ores, and concentrates.

BERYLLIUM

Beryl, the chief ore of beryllium, occurs in pigmatites which are associated with granites and is found in Rajasthan, Tamil Nadu, Jammu and Kashmir, and Bihar. At one time, almost the entire beryl output of India was being exported but the Atomic Energy Establishment (AEE) (a Government of India undertaking) now handles its production and sale. Although beryllium is not produced on a commercial basis in India, substantial groundwork has been done at the Bhabha Atomic Research Centre (BARC), Bombay, in beryllium production technology.

CHROMIUM

The principal chromite deposits of India are located in Singhbhum district (Bihar), Karnataka, Krishna and Sawantwadi (Maharashtra), and Keonjhar district (Orissa).

India produces chromite on a very large scale—approximately 350,698 tons per annum in 1977, of which Orissa accounted for almost 97 per cent. The chromite reserves of India, although estimated to be limited to about 17 million tons, should be able to meet the domestic requirement for a long period, and a production of 10,000 tons per annum can be sustained for years.

NICKEL AND COBALT

Until recently, exploitable deposits of cobalt- and nickel-bearing minerals were considered non-existent in India. Of late, however, several low-grade nickeliferrous deposits have been discovered, which are serpentinous, lateritic, or sulphidic in nature. The copper ore belt passing through Singhbhum (Bihar) contains also a nickel ore body which may provide 1000 tons of nickel annually. In fact, India's nickel reserves are about 100 million tons, of which 6.5 million tons, averaging 0.85 per cent nickel, are located at Sukinada (Orissa). Apart from the ores, copper tailings and the anode sludge from copper plants could turn out to be an important source of nickel. Nickel has also been found associated, in very minute quantities, with the gold-quartz reefs at Kolar (Karnataka) and the uranium ores at Jaduguda (Bihar). In spite of the aforestated sources, the only domestic supply of nickel, at present, comes from the copper smelters at Khetri (Rajasthan), where nickel sulphate is recovered as a byproduct, the amount recovered in 1977–78 being 150 tons.

It may be noted that traces of cobalt have been found along with the copper ores of Khetri and the manganese ores of Kalahandi (Orissa).

At present, neither nickel nor cobalt is produced in India on a commercial scale, and the domestic requirements are met by imports. A method has yet to be found for the economic reduction of the Sukinada laterite ore with about 1 per cent nickel content.

CADMIUM

Cadmium is recovered as a byproduct from the zinc smelters at Debari (Rajasthan), Visakhapatnam (Andhra Pradesh), and Alwaye (Kerala). Indigenous sources meet most of the domestic cadmium requirements.

COPPER

India has about 370 million tons of copper reserves, and the average copper content varies from 1 per cent to 2.5 per cent. About 90 per cent of these reserves are spread over Bihar, Rajasthan, and Madhya Pradesh, the most important deposits being located in the Singhbhum copper belt in Bihar. By world standards, the copper reserves of India are small. However, the Geological Survey of India is constantly exploring for new reserves. The Mineral Exploration Corporation has recently established the existence of 58 million tons of copper reserves at Malanjkhand (Madhya Pradesh). A project to mine two million tons of ore a year, from which copper concentrates can be produced, has been cleared by the Planning Commission of India.

At present, Hindustan Copper Limited (HCL) is the sole producer of copper in India and is able to meet about 42 per cent of the country's requirements, i.e., about 23,000 tons in 1977–78. The future production is expected to go up to 40,000 tons.

GOLD

India's gold reserves are estimated to be 3.15 million tons (1977); a majority of them located in Karnataka. The gold content of these reserves ranges from 5.65 gm/ton to 19.98 gm/ton of ore. Minor deposits of vein gold have also been found in the Hutti gold field (Karnataka). The entire production of gold in India is by the Government of India's Bharat Gold Mines Limited (BGML) and the Karnataka state-owned Hutti Gold Mines Company.

Gold tailing dumps, which have accumulated over the years, contain scheelite. BGML proposes to recover this scheelite (from which ferrotungsten can be obtained) from the dumps.

In 1977, the gold production in India was 2854 kg compared with 3132 kg in 1976. This decrease can be attributed to the shrinking reserves, because of which, the gold production is unlikely to go up in the future, unless, of course, new reserves are found.

SILVER

India has no reserves of silver ores. However, small quantities of silver are recovered as a by-product during the indigenous refining of gold, copper, and lead; the major part coming from the lead smelters at Tundoo (Bihar) and the gold mines in Karnataka.

LEAD AND ZINC

India has about 140 million tons of lead-zinc ores, of which nearly 118 million tons are located

Table 3.10 Estimated Reserves of Lead-Zinc Ores (after Kapur, 1978)

Classification	Location of deposit	Total ore (million tons)	Production capacity (tons/day)
Operating mines	Mochia (Rajasthan)	28.61	2000
	Balaria (Rajasthan)	19.81	2000
	Rajapura-Dariba (Rajasthan)	33.78	3000
	Agnigundala (Andhra Pradesh)	9.84	300
	Rangpo (Assam)	0.12	100
Approved projects	Zawar (Rajasthan)	15.22	1500
	Ambamata (Gujarat)	6.19	1200
	Sargipalli (Orissa)	1.89	500
	Borai (Rajasthan)	11.20	1500
Advanced exploration projects	Deri (Rajasthan)	0.85	200
	Mamandur (Tamil Nadu)	1.00	200
Projects under exploration	Bhilwara (Rajasthan)	7.47	1000
	Gorubathan (West Bengal)	2.00	500
	Basantgarli (Rajasthan)	1.62	300

MAGNESIUM

India has extensive deposits of magnesium in the form of magnesite ($MgCO_3$), chiefly found in the Chalk Hills of Salem district (Tamil Nadu). The estimated reserves of magnesite here have been put at 82.5 million tons up to a depth of 30 m and 330 million tons up to a depth of 150 m. The deposit is of a high grade, the average magnesia content being 46 per cent or above. On the whole, India's *in situ* magnesite reserves are estimated to be 524 million tons, of which the existence of 33 million tons has been conclusively established. Apart from Salem district, the other important magnesium deposits are located in southern Karnataka and Uttar Pradesh. Smaller deposits are found in Idar (Maharashtra), Kurnool (Andhra Pradesh), Tiruchirapalli (Tamil Nadu), Coorg (Karnataka), Dungarpur (Rajasthan), and Singhbhum. It should be noted that in some of these deposits, magnesium is present as dolomite ($CaCO_3 \cdot MgCO_3$).

Widespread reserves of dolomite and magnesium limestones are found in Tamil Nadu, Andhra Pradesh, Bihar, Madhya Pradesh, Rajasthan, and Orissa. These reserves have not yet been accurately assessed, but should be adequate to fulfil India's increasing requirements of magnesium. Another source of magnesium that could be exploited in the near future is the Indian Ocean, which contains, on an average, 0.6 per cent $MgCl_2$.

MOLYBDENUM

There are no commercially viable reserves of molybdenum in India, but its ores are found as primary molybdenite (MoS_2) and as a base metal sulphide containing small quantities of molybdenum. Exploration surveys in Andhra Pradesh and Tamil Nadu have shown that primary molybdenite occurs in the quartz veins that traverse porphyritic granites and, at places, in the granite itself. Molybdenum in a base metal sulphide that is in association with copper ores is found at Rakha and Bhatin in the Singhbhum district. Experiments have shown the concentration of molybdenum in the Rakha ore sample to be approximately 0.011 per cent and that in the Bhatin ore sample to be 0.1 per cent. Preliminary beneficiation of the molybdenum ore has indicated the recovery during concentration to be 95 per cent.

TIN

Tin is not extracted on a commercial scale in India although tin deposits have been detected in Ranchi and Hazaribagh districts of Bihar. The entire present requirement of almost 10,000 tons per year is being met by imports.

TITANIUM

Abundant quantities of ilmenite ($FeO \cdot TiO_2$) are found in the beach sands along a 160-km stretch of the Kerala coast. In fact, a particular 23-km coastal strip contains 35 million tons of ilmenite and three million tons of rutile (TiO_2). The ilmenite from Kerala contains a high percentage (55 per cent) of titanium. Smaller deposits of ilmenite occur near Tuticorin (Tamil Nadu), Waltair (Andhra Pradesh), and Ganjam district (Orissa). The total reserves of ilmenite in the form of beach sands are estimated to be 133 million tons. Apart from the beach sand deposits, small quantities of massive and crystalline ilmenite are found in Bhagalpur district (Bihar) and Kisengarh and Jodhpur (Rajasthan). Almost the entire volume of the metal concentrates so far produced has been exported.

The beach sands of Kerala contain a mixture of mineral sands whose specific gravities vary from 2.3 (silica) to 4.9 (monazite). Table 3.11 gives the mineralogical compositions of the beach