EXTENT & GEOGRAPHICAL DISTRIBUTION OF INDIAN ORES & MINERALS.

THE rock systems of India possess in varying degree the minerals and ores which are mainly classified as (1) Ferrous and ferro-alloy group; (2) Non-ferrous and base metal group; (3) Non-metallic and refractory group; (4) Strategic minerals group; (5) Fertilizer minerals group etc. depending on their usage they are put in. Except in the case of minerals such as iron ore, aluminium ore, titanium ore, mica and a few other minerals, the resources in economic minerals and metals are, however, limited.

The major iron ore deposits are mostly confined to the South Eastern Region of India, in the States of Orissa, Bihar, and Madhya Pradesh, besides some deposits in Andhra Pradesh, Tamil Nadu and Karnataka, and a good number of smaller deposits in the other parts of the country, like Goa, U.P., Maharastra etc. The most important manganese ore deposits lie in Orissa, Karnataka, Madhya Pradesh, Maharastra, Andhra Pradesh and Goa. Titaniferous and vanadiferous iron ores are present in Karnataka, Bihar, Maharastra and Orissa. Chromite deposits are present in the States of Orissa, Karnataka, Andhra Pradesh, Maharastra, Bihar, Tamil Nadu, Manipur and the Union territory of Andaman Islands, of which Orissa produces the bulk of the output.

Among the important base metal mineral deposits workable reserves of copper ore are indicated in Andhra Pradesh, Bihar, Karnataka, Madhya Pradesh and Rajasthan. Lead-zinc ore deposits are very limited and confined to Andhra Pradesh, Gujarat, Orissa and Rajasthan. The important bauxite deposits are found in Maharastra, Madhya Pradesh, Gujarat, Bihar, Tamil Nadu, Orissa, Goa, Uttar Pradesh, Kerala and Jammu-Kashmir*. Nickel ores occur in Orissa and Bihar according to the latest geological findings.

Under the non-metallic and refractory mineral group, limestone is the most widely distributed through out the country, the most important deposits being situated in Andhra Pradesh, Bihar, Gujarat, Karnataka, Kashmir, Kerala, Madhya Pradesh, Maharastra, Orissa, Punjab, Rajasthan, Tamil Nadu and Uttar Pradesh. Likewise china clay has wide distribution in the States of Bihar, Delhi, Gujarat, Karnataka, Kerala, Orissa, and West Bengal. Quartz and Silica Sand occur in Rajasthan. The mineral dolomite is widely distributed in the country. Kyanite and Sillimanite are restricted to Bihar, Meghalaya and Maharastra mainly.

Under the strategic minerals wolframite and scheelite are limitedly present in meagre quantities in Rajasthan, Maharastra, Bihar, Andhra Pradesh, Karnataka, Tamil Nadu and Gujarat. Graphite occurs in almost all States in the country even though the main deposits are situated in Andhra Pradesh and Orissa. Fluorspar has been found to occur in the States of Gujarat, Rajasthan and Madhya Pradesh. Molybdenite occurs in Tamil Nadu and Bihar.

Among the fertilizer group of minerals apatite is confined to Bihar and Andhra Pradesh and Tamil Nadu (Phosphatic modules). The Rock Phosphate (Phosphorite) is present in Rajasthan and Uttar Pradesh mainly. Pyrite occurs in Bihar and Rajasthan. Gypsum deposits occur mainly in Rajasthan and Jammu-Kashmir. Minerals like corundum, diamond, felspar, magnesite, ochre, mica steatite and vermiculite also occur with different distribution. Coal, lignite and oil do occur in India, but they are not dealt with presently as they do not fall in purview of this work.

Recent finds: East Coast and Santhal Parganas in Bihar

Broad Specifications

For purchase of iron ore the Minerals and Metals Trading Corporation which is mainly handling export market has adopted the following specifications :

	Type	Grade Fe %	Size of the ore
(1)	Blast Furnace Grade (B.F. Grade)	58-60	12 mm —100 mm (undersize and oversize allowed upto 10%)
(2)	Export Grade	63-65	12 mm —200 mm
(3)	S.M.S. Grade (domestic)	64 and above	50 mm 200 mm (lump ore only)

Ores used by most of the Steel Plants in the country are of the following broad specifications.

Size		10-200 mm
Fe % content	=	57-63%
$SiO_2 + Al_2O_3$	=	less than 10%
$SiO_2 : Al_2O_3$	=	1 : 1 to 1 : 1.5
P	=	less than 0.15%
S	=	less than 0.02%

However, the present day trend has been to minimise the impurities and delterious constitunets outside the blast furnace by adopting beneficiation techniques. The feed size came down to +10 mm —50 mm and may perhaps be further clamped in future to —15 mm. Higher Fe content (63-68%), less than 4-5% SiO_2 with positive SiO_2/Al_2O_3 ratio, Al_2O_3 not exceeding 2% will be the present day preferentials. Sinters and pellets will be increasingly used.

Production, Domestic Consumption and Export Demand

Classifying the Indian iron ores on the basis of regional occurrences and linking them with port export, the Task Force for Ferrous group, Planning Commission, 1972 has projected production for domestic consumption and exports at the end of the Fifth and Sixth Plan periods as given in Table 1.1. Actual production of iron ore and foreign exchange earned from exports in the years from 1968-69 to 1971-72 and production projected and export set for in the years to come are given in Table 1.2. A recent estimate of iron ore reserve by G.S.I. has put hematite variety as 10,523 million tonnes and magnetite variety as 2,748 million tonnes.

National Council of Applied Economic Research (NCAER) studies asserted that ample reserves exist in the country, to meet export as the major foreign exchange earner, and for supplies to meet the expanding domestic iron and steel industry, enough to permit an export target of 45 million tonnes of ore per year for the next fifty years. Production of high grade lumpy ore, which is required for export market, leaves behind in the mines almost an equal quantity of fines of equally good grade which cannot be readily used unless they are agglomerated. As such the necessity of agglomeration has arisen which is the only way to make use of the enormous quantity of fines produced and accumulated during mechanised mining and at the same time thus conserving our mineral resources, which will be otherwise left as waste dumps at the mine site creating big problems of their clearance. India's total production exports and imports of iron ore are given in Table 1.3. The country's metal production, export and import are given in Tables 1.4 & 1.5.

From the studies of the Task Force of the Steel Ministry and the projections made by the Planning Commission, it has emerged that the steel development programme in the Fifth Plan should be drawn in such a manner that about 8.8 million tonnes of saleable steel would be available by 1978-79 to meet domestic consumption. The existing integrated steel plants have total capacity of 8.9 million ingot tonnes of steel, equivalent to 6.5 million tonnes of finished steel per annum. The increased demand for steel by 1978-79 is proposed to be met through the expansion of Bhilai Steel Plant from its present capacity of 2.5 million ingot tonnes to 4.0 million ingot tonnes and by the expansion of Bokaro, on a continuing basis, to a capacity of 4.75 million ingot tonnes. With the expansion of Bhilai and Bokaro Plants and with the capacity utilisation possible in the other integrated plants, it is estimated that finished steel available by 1978-79 would be about 8.8 million tonnes.

TABLE 1.1—PROJECTED PRODUCTION OF IRON ORE FOR 1978-79 AND 1983-84 AGAINST AVAILABLE RESERVES (IN MILLION TONNES)

Areas	Total Reserves	Reserves proved	Production and exports 1970-71	Projected 1978-79	Projected 1983-84
Bihar & Orissa (Noamundi, Kiriburu, Meghataburu, Gua, Manoharpur)	5613	1967	Production 11.4	25.6	33.3
			Export 4.1	9.0	11.0
M.P. East & Maharastra (Bailadila, Dallipahar, Roughat etc.)	2969	1444	Production 7.2	21.8	24.7
			Export 3.3	12.0	12.0
Karnataka (Bellary-Hospet, Chikmagalur etc.)	1450	634	Production 3.5	9.4	17.3
			Export 3.2	6.0	11.0
Andhra	16	—	—	—	—
Kudermukh	1014	—	—	—	—
Goa & S.W.	462	124	Production 9.6	9.0	14.1
			Export 10.2	9.0	11.0
Tamil Nadu (Salem)	306		Production	7.8	11.1
			Export	7.0	10.0
Punjab	30		—	—	—
Rajasthan, U.P.	—		—	—	—

Sources: I.B.M. & G.S.I.
N.M.D.C., TASK Force for Ferrous Group, Planning Commission.

TABLE 1.2—PRODUCTION, EXPORTS AND PRICES OF IRON ORE AND PROJECTIONS OF PRODUCTIONS IN 1973-74, 78-79, 83-84 (IN MILLION TONNES)

Fiscal Year	Total Production	Internal Consumption	Export tonnage	Foreign exchange earnings Rs. crores	Price of exported U.S. $/t.	Price of imported steel U.S. $/t.
1965-66	24.40	12.10				
1966-67	26.73					
1967-68	27.96					
1968-69	28.70	12.80	15.90	89.60	7.50	
1969-70	29.22	11.53	17.69	100.45	7.36	252.41
1970-71	31.60	10.78	20.81	115.44	7.38	274.70
1971-72	34.26			113.06	7.18	
1972-73	35.47					
1973-74	34.98	15.5	25.50			
1974-75	35.48					
1975-76	41.29					
1978-79	74.00	31.0	43.00			
1983-84	100.00	45.0	55.00			

Source: Industrial Development of India (1971) and Statistical Information Bulletin of Indian Bureau of Mines.

TABLE 1.3—IRON ORE PRODUCTION, EXPORT AND IMPORT (IN TONNES)

Year	Production	Export	Import
1966	26,733,361	13,658,000	118
1967	25,855,161	13,574,000	Nil
1968	27,960,590	15,638,000	Nil
1969	29,566,772	15,118,000	169
1970	31,366,315	21,205,000	153
1971	34,310,592	19,355,000	373
1972	35,475,692	21,864,000	218
1973	35,563,228	21,285,000	275
1974	35,485,276	21,900,000	322
1975	41,405,301	22,796,000	

Source: I.B.M.

TABLE 1.5—IMPORT FIGURES OF IRON & STEEL METALS INTO INDIA (IN TONNES)

Year	Iron & Steel & Scrap
1966	497,116
1967	516,025
1968	435,338
1969	428,417
1970	606,881
1971	1,220,731
1972	1,267,347
1973	1,033,493
1974	1,239,048
1975	741,682

Source: I.B.M.

TABLE 1.4—METAL PRODUCTION AND EXPORT

Year	Production (in '000 tonnes)			Exports (in tons.)	
	Pig Iron	Steel	Steel Ingots	Iron (Pig. Cast etc.)	Iron & Steel & Scrap
1966	7,041	4,492	6,608	64,710	785,190
1967	6,867	4,163	6,387	510,492	1,057,992
1968	7,079	4,476	6,448	739,167	1,309,640
1969	7,334	5,072	6,475	521,484	1,178,427
1970	7,013	4,931	6,232	531,836	1,007,869
1971	6,697	4,659	5,322	351,301	546,201
1972	7,207	5,175	6,842	224,382	310,493
1973	6,474	3,765	5,953	169,602	293,155
1974	7,342	5,033	6,820	218,594	315,129
1975	8,376	4,361	7,082	371,964	498,410

Source: I.B.M.

(2) MANGANESE ORE

Reserves

According to inventory prepared jointly by IBM & GSI as on 1.1.1975 total reserves of manganese ore of all categories are of the order of 105.48 million tonnes, of which 14 million tonnes are of metallurgical grade with over 46% Mn content. The total reserves are given in Table 1.6.

TABLE 1.6—ZONE WISE AND GRADE WISE RESERVES OF MANGANESE ORE INDIA AS ON 1.1.1975 (IN MILLION TONNES)

Zone	+46% Mn	35-46% Mn	30-35% Mn	Below 30% Mn	Unclassified	Total
A	4.6	7.9	—	16.2	2.7	30.9
B	9.4	31.7	4.7	1.0	—	46.8
C	—	—	1.2	—	—	1.2
D(I)	—	13.5	—	—	—	13.5
D(II)	—	2.2	—	0.2	—	2.4
E	—	—	4.0	—	—	4.0
F	—	—	—	3.3	—	3.3
G	—	3.2	—	—	—	3.2
Total	14.0	58.0	9.9	20.7	2.7	105.3

Zone-A :— Orissa. (i) Jamda-Koira Valley
(ii) Koraput-Bolangir etc.

Zone-B :— Madhya Pradesh (Balaghat Dist) and Maharastra (Bhandara and Nagpur District).

Zone-C :— Andhra Pradesh (Srikakulam Dist).

Zone-D(I) :— Karnataka (Bellary Dist).

Zone-D(II) :— Karnataka (Shimoga, Chitradurga and Tumkur Dists.)

Zone-E :— Karnataka (Kalinadi area of North Kanara Dist).

Zone-F :— Goa

Zone-G :— Gujarat (Baroda and Panch mahal Dist), and Rajasthan (Banswara Dist).

Specifications

The specification of manganese ore varies with the use to which it is put to. It can be used for metallurgical purposes, chemical purposes, dry battery manufacture, and in glass and ceramic industries.

(i) *Metallurgical Purposes*

For ferro-manganese industry, the ore should be lumpy and of following composition.

Mn	48% minimum
Fe	6% maximum
SiO_2	4% maximum
Al_2O_3	4% maximum
P	0.12% maximum

The Mn : Fe ratio should not be less than 6 : 1 but 7 : 1 to 7.5 : 1 is preferred. Pb, As, Zn etc. if present, should only be in traces.

For silico-manganese manufacture, the ore to be used for the manufacture of silico-manganese may have lower percentage of Mn down to 35% with rather more silica.

(ii) *Chemical Purposes*

High grade ore is generally used. It is rather difficult to specify the chemical grade manganese ore, but, in general, ores containing 75% MnO_2 with not more than 1.5% Fe, 1% Al_2O_3, 6% SiO_2 and 0.02% Cu are used. In the case of ores suitable for use in chemical industries as oxidising agent, the Mn content is not so much important as the percentage of the available oxygen.

(iii) *Dry Battery Industry*

The ore must have a high MnO_2 and low Fe content and should possess a certain degree of porosity and be of moderate hardness. It should be free from the compounds of metals which are electro-negative to zinc (container) such as Cu, Ni, Co, As, Pb and Sb. The U.S. National Stockpile specification for Natural grade is as follows :

Available Oxygen (MnO_2)	75% minimum
Mn	48% minimum
Fe (soluble in Hcl)	3% maximum
SiO_2	10% maximum

However, the major battery manufacturers in India, Viz., Union Carbide, India, Ltd., consume Mn ore of the following specifications.

	A grade		D grade		R grade	
MnO_2	84.0%	Min.	84.76%	Min.	84.0%	Min.
Iron including magnetic iron	2.0%	Max.	1.4%	Max.	2.0%	Max.
Cu	0.03%	Max.	0.005%	Max.	0.03%	Max.
Ni and Co	0.1%	Max.	0.008%	Max.	0.1%	Max.
Nitrates as Nitrogen	0.005%	Max.	0.11%	Max.	0.1%	Max.
Moisture	1.0%	Max.	1.0%	Max.	1.0%	Max.

Estrella Battery Company desires that the ore should contain $MnO_2=80\%$ minimum, with acid insolubles 10.0% maximum and $Al_2O_3=10\%$ maximum. The crystal structure desired is gamma MnO_2 phase. Havero Industries want MnO_2 to be 85-95% in the ore.

(iv) *Glass and Ceramic Industries*

The ore required is similar to battery grade. A high ratio of MnO_2 to Fe is desirable. Some special glasses require 90% MnO_2 and 0.5% Fe. Siliceous pyrolusite (MnO_2) is acceptable but not carbonaceous pyrolusite.

Production, Domestic Consumption and Export Demand

Even though Manganese ore occurrances are scattered throughout the country, the major producing areas are from Orissa, Karnataka, Madhya Pradesh, Maharastra and Andhra Pradesh which together put 95% of all-India production (excluding Goa). Goa has got its own peculiarities regarding ore quality and production. It produces ferruginous manganese ore with annual production ranging from about 43,000 tonnes (1967) to about 4,00,000 tonnes (1972). Besides the ferruginous manganese ore, it also produces manganiferrous iron ore locally known as 'black iron' containing less than 10% Mn with a minimum total metal content (iron and manganese) of more than 52%.

Bihar-Orissa Belt

The bulk of the reserves are in Orissa and those in Bihar are of secondary importance. The ores are intermingled with lateritic and other gangue minerals. High grade ore having Mn content of 40% and above is comparatively low. The rest are low grade with Mn content varying from 30 to 40%. The phosphorous content varies from 0.1% to 0.53%, Fe% from 23% to 35% and SiO_2% from 7% to 10%.

Balaghat Manganese Belt

Generally the ores are high grade lumpy with low phosphorous and ideal ores for the manufacture of ferro-manganese. The Mn content varies from 49% to 54%, Fe from 5% to 9% SiO_2 from 1.6% to 6.0%, P from 0.04% to 0.24%. Some low grade ores are also present.

Mysore ores consist of both ferruginous as well as siliceous ores while Andhra ores consist of siliceous ores in general with some ferruginous ores. Some high grade ores are present. In general the phosphorous content is high.

Manganese ore production of India including the important producing States is given in Tables 1.7 and 1.8.

Demand Projections 1971-72 to 1983-84

Depending upon the amount of manganese content present in the ore it is classified into

TABLE 1.7—PRODUCTION OF MANGANESE ORE IN TONNES

Year	Production
1964	14,07,339
1965	16,46,814
1966	17,10,480
1967	16,16,992
1968	16,10,078
1969	14,85,787
1970	17,02,030
1971	18,40,523
1972	16,23,773
1973	14,51,000
1974	15,01,856
1975	16,05,000

Source: I.B.M.

TABLE 1.8—PRODUCTION OF MANGANESE ORE IN DIFFERENT STATES. AVERAGE ANNUAL PRODUCTION (1957-1970) IN TONNES

State	High Grade +46% Mn	Medium Grade +38%-46% Mn	Low Grade —38% Mn	TOTAL
1. Orissa	58,000	1,37,000	2,03,000	4,52,000
2. Karnataka	10,000	1,70,000	1,05,000	2,85,000
3. Madhya Pradesh	1,66,000	72,000	22,000	2,60,000
4. Maharastra	1,42,000	83,000	22,000	2,47,000
5. Andhra Pradesh	—	42,000 (1957)	1,55,000 (1957)	1,97,000 (1957)
6. Goa	—	—	4,02,000 (1962)	4,02,000 (1962)
Average (1961-70)	—	—	1,61,000	1,61,000

Source: Report of working group of Manganese under the Task Force on Ferrous group of Minerals.

three categories, viz. high grade (Mn 46% and over), medium grade (Mn 36%-46%) and low grade (Mn 30%-35%). Each of them is put into use for different industries in larger or smaller amounts. Thus the high grade ore is mostly utilised in steel making for the manufacture of ferro-manganese alloy. A small quantity is also used in the manufacture of dry battery cells; other industries which use in minor quantities are chemical, paint, refractory, glass and ceramics. The low grade ore is utilised in the manufacture of pig iron in the blast furnace. There is export market for all grades of ores and ferro-manganese as well.

Internal Consumption

Ore for Ferro-manganese production for steel plants

The projected production pattern of steel ingot in the existing steel plants and those proposed to be set up during the Fifth and Sixth Plan periods along with their related ferro-manganese requirement are given in Table 1.9. Ferro-manganese that is required by the steel plants of the H.S.L. should contain 74-78% Mn, with carbon below 7.5%, Silicon below 1.5%, P below 0.35% and S less than 0.05%. The manganese ore required for the manufacture of ferro-manganese should be of high grade with Fe 6-8%, SiO_2 less than 9%, Al_2O_3 less than 3.0%, and P less than 0.18%. A minimum Mn/Fe ratio of 6 : 1 is to be maintained.

Ore for Blast Furnace

The manganese ore used in the blast furnace can be of low grade with about 30% Mn, P less than 0.18% and low silica.

Other uses

Next to iron and steel industry, manganese ore is used in the manufacture of dry battery cells followed by chemical, paint, refractory, glass and ceramic industries. Very high grade ore consisting predominantly of gamma MnO_2 phase, is required for dry battery manufacture. Though high grade peroxide ore (pyrolusite) is available in India (Orissa etc.) it does not fulfil the gamma phase requirement. To meet this requirement a substantial quantities of high grade ore are being imported for manufacture of dry batteries for the defence and transmission which require a continuous draw of electricity. For other purposes like manufacture of torch cells etc., where continuous draw of electricity is not required the indigenous ore or a blend of indigenous and imported ore is used. The present consumption ratio of indigenous ore and imported ore for dry cells industry is 1 : 1.7.

TABLE 1.9—PROJECTED PRODUCTION OF HOT METALS AND THE REQUIREMENT OF LOW GRADE MANGANESE ORE BY THE END OF 4TH. 5TH & 6TH PLAN PERIOD

Steel Plants	Production of hot metal in thousand tonnes			Consumption norm	Requirement of low grade Manganese ore in thousand tonnes			Source of supply of ore
	1973-74	1978-79	1983-84		1973-74	1978-79	1983-84	
1. TISCO	1,850	1,950	2,600	0.037	68,450	72,150	96,200	Orissa—Bihar
2. IISCO	1,300	1,300	1,950	0.035	45,500	45,500	68,250	—do—
3. Bhilai	2,925	4,000	5,200	0.053	155,025	212,000	275,600	M.P.,—Maharastra
4. Rourkela	2,106	1,600	2,340	0.034	71,604	54,400	79,560	Orissa—Bihar
5. Durgapur	1,664	1,700	2,600	0.035	58,240	59,500	91,000	—do—
6. Bokaro	1,035	4,585	5,850	0.045	46,575	206,325	285,250	—do—
7. Vizag	—	—	5,200	0.045	—	—	234,000	Orissa & Andhra Pradesh
8. Vijayanagar	—	—	5,200	0.045	—	—	234,000	Karnataka & Goa
9. VII Plant (Bihar-Orissa)	—	—	2,600	0.045	—	—	177,000	Orissa & Bihar
10. VIII Plant (Karnataka)	—	—	2,600	0.045	—	—	177,000	Karnataka & Goa
11. IX Plant (Orissa)	—	—	2,600	0.045	—	—	177,000	Orissa & Bihar
12. X Plant (Bailadila)	—	—	2,600	0.045	—	—	177,000	M.P. & Maharastra
13. XI Plant (Rowghat)	—	—	2,600	0.045	—	—	177,000	—do—
14. XII Plant (Goa)	—	—	2,600	0.045	—	—	177,000	Karnataka & Goa
15. Other Plants	209	868	1,400	0.045	9,405	39,060	63,000	Karnataka
Total	11,089	16,003	47,940		454,799	688,935	2466,860	

Source: Working group on Manganese under the Task Force on Ferrous group of minerals, Dept. of Mines, Government of India.

In 1969-70 about 11,300 tonnes of indigenous manganese ore has been used for manufacture of 479 million number of dry batteries, which works out to about 23.6 tonnes/1 million batteries. It is anticipated that the production of dry cells will reach figures of 850 million in 1973-74, 1500 million in 1978-79 and 2500 million in 1983-84, consuming 20,000, 35,000 and 58,000 tonnes respectively of indigenous high grade ore. Comparatively meagre amount of ore is used for other industries like chemical, paint, refractory etc.

Export

Until late 1950s for nearly two decades India maintained to be one of the major exporting countries of manganese ore and in the year 1957 its share of the total world exports was 30% in manganese ore. But lately from 1960 there has been a steady decline and it touched to 15% in 1970.

It is now seen that India will not have any exportable surplus of manganese ore in the future. The actual export figures in 1972 are 8.61 lakh tonnes and in 1973 are 6.92 lakh tonnes, 10.346 lakh tonnes in 1974 and 7.9336 lakhs tonnes in 1975.

A study of the pattern of consumption of manganese ore for internal consumption and export market reveals that the demand will rise from 2.43 million tonnes (end of Fourth Plan) to 3.15 million tonnes (end of Fifth Plan) and 4.95 million tonnes (end of Sixth Plan) if the same export level is to be maintained. The export figures in 1965, 66 and 67 as given by M.M.T.C. are 13.31 lakh tonnes, 11.85 lakh tonnes and 10.43 lakh tonnes respectively showing a decline, which is attributed to several factors—some economic and some political.

With the anticipated increase in the coming years in the steel production in the country the requirements of manganese ore both for the blast furnace direct feed as well as for the ferro-manganese production will increase tremendously. In order to meet the domestic demand as well as export demand (if at all export is to continue) the production of manganese ore has, therefore, to increase rapidly. This naturally needs the correct estimate of the reserves and proper utilisation of the ore, as in recent times there is a wide difference between the inferred in-situ reserves of 105.48 million tonnes of all categories and the actually proved reserves of the order of 8.0 million tonnes, even though this figure may be improved only after further exploration is taken up and correct assessment done in future and new resources are proved. Keeping this aspect in view a long-term perspective may not be possible to be evolved and a change in priority would have to be given to meet the internal demand first, meeting the export only after new and additional resources are proved.

(3) CHROMITE

Chromite is mainly used for the manufacture of ferro-chrome which in turn is used in the manufacture of stainless steel and other high temperature alloys. It is also used in refractory and chemical industries. Since chromium-alloys find application in defence armaments, this mineral is of strategic importance. As such, although the proved and indicated reserves may seem to be adequate to meet the demands at the present rate of production during the next decade or two, the position may become critical by the end of the present century unless some advance measures are taken for augmenting and conservation of the reserves.

Reserves

According to inventory prepared jointly by IBM & GSI, as on 1-1-1975, the total reserves of chromite ore of all grades are estimated to be of the order of 17.30 million tonnes, in which measured category will be 2.35 million tonnes, indicated category 6.97 million tonnes, inferred reserves are 7.98 million tonnes.

Chromite occurs in the States of Orissa (bulk production), Karnataka, Andhra Pradesh, Maharastra, Bihar, Tamilnadu, Jammu-Kashmir and the Union Territory of Andaman Islands.

The total reserves as on 1-5-1975, according to G.S.I. is given in Table 1.10.

There is no proper estimation of gradewise reserves. However, about 7.5 million tonnes of total reserves are of metallurgical grade ($Cr_2 0_3$ 45% and above), of which 6.7 million tonnes comes from Orissa. Similarly 9.8 million tonnes of total reserves are of refractory grade ($Cr_2 0_3$ less than 45%), of which 7.8 million tonnes comes from Orissa.

TABLE 1.10—SUMMARY OF CHROMITE RESERVES AS ON 1-1-1975 (IN MILLION TONNES)

	Measured	Indicated	Inferred	Total
All India	2.35 (0.27 lump 2.08 fine)	6.97 (2.30 lump 4.32 fine 0.35 lump & fine)	7.98 (1.04 lump (3.97 fine 2.97 lump & fine)	17.30 (3.61 lump 10.37 fine 3.32 lump & fine)
Orissa	2.21 (0.19 lump 2.02 fine)	6.71 (2.16 lump 4.23 fine 0.32 lump & fine)	5.88 (1.04 lump 3.97 fine 0.87 lump & fine)	14.80 (3.39 lump 10.22 fine 1.19 lump & fine)

The occurrences of chromite in India are given in Table 1.11.

Specifications for Different Uses

Commercially chromite can be divided into three categories depending on its use as (i) high grade for metallurgical use with Cr_2O_3% above 48.0%, (ii) medium grade for chemical use with Cr_2O_3% more than 40%, and (iii) low grade for refractory use with Cr_2O_3% less than 40%.

The low grade variety is not exported at present.

TABLE 1.11—OCCURRENCES OF CHROMITE IN INDIA

Locality	Grade (Cr_2O_3%)	Remarks
1. Kondapalle (A.P.)	39-55.6	Deposits abandoned since 1967.
2. Jojohatu (Bihar)	53.4	Mining stopped in 1966. Small production reported in 1970.
3. South-West base of Shevaroy Hill (T.N.)	35.6-44.5	Workability to be tested.
4. Sittampundi (T.N.)	17.96-31.44	Amenable to beneficiation.
5. Pauni (Maharastra)	39.9-52.5	Spread over small area with chances of fresh discovery.
6. Vagda (Maharastra)	36.92-37.5	Amenable to beneficiation but high iron has to be reduced for metallurgical purposes.
7. Kankauli (Maharashtra)	36.49	—do—
8. Heddari-Devangire Nuggihalli Schist Belt, some localities including Byrapur (Karnataka)	Variable 48-50 (Byrapur Ore)	Thorough investigations needed. Byrapur deposits are the best and largest.
9. Shinduvalli (Karnataka)	50.0	—
10. Sukinda Chromite Belt (Orissa)	Metallurgical to refractory.	Largest and the best reserves. 80% of Indian reserves.
11. Nausahi (Orissa)	All grades	6% of the domestic reserves. Exploration not commensurate with the promise of the deposits.
12. Moyurbhanj (Orissa)	Inferior	Prospecting recommended.
13. Dras and Tashgam (Jammu & Kashmir)	—	Expected good reserves. Means of communication to be developed.
14. Chakrea (Andaman, Nicobar)	—	Indications so far reported.

(a) *Metallurgical—For Ferro-chrome Manufacture of Different Types*

Size: Hard and lumpy ore of about 150 mm size, with not more than 10-15% of 12 mm size material.

Cr_2O_3 : 48% Minimum
Al_2O_3 + MgO : 25% Maximum
SiO_2 : 5.0% ,,
Sulphur : 0.5% ,,
Phosphorous : 0.2% ,,
Cr : Fe ratio : 2.8:1 (Min).

(b) *Chemical—For Chromium Chemicals*

Cr_2O_3	: 44.0% Min.	Cr_2O_3	= 48-50%
Al_2O_3	: 15.0% Max.	SiO_2	= 6%
FeO	: 20.0% Max.	Cr : Fe	= 1.6 : 1

(c) *Refractory—Chrome-bricks and Chrome-cement*

Cr_2O_3	: 36.38%	(Cr_2O_3 + Al_2O_3 > 57%)
FeO	: 10-21%	FeO = 20% Max.
SiO_2	: 6% Max.	SiO_2 = 10% Max.

(d) *Other minor uses For tiles and bricks and painting yellow lines on roads — No rigid specifications*

In India, chromite of good quality suitable for use in metallurgical industry is available from Orissa and in limited quantities from Bihar and Karnataka. Chromite from Tamil Nadu and Maharastra is aluminous and highly ferruginous and as such may be used for refractory purposes.

Production, Domestic Consumption and Export Demand

The production trends, domestic consumption and export during the last few years are given in the Table 1.12, as recorded by Indian Bureau of Mines and M.M.T.C.

Domestic consumption of chromite for metallurgical use in the early fifties is low in comparison to that of other countries having steel industry. It actually began making increased use from 1965 onwards with the starting of production of ferro-chrome in the different ferro-alloy units, like Garividi, Jajpur Road etc. In the same way increased consumption of the ore is seen in refractory industry in recent years. In the chemical industry during subsequent years after 1962 a decline in consumption of the ore is noticed. But it is anticipated that in the near future the indigenous consumption will be increased with its increased demand for the indigenous automobile industry, which is the biggest consumer of dichromate chemicals.

Chromite is being exported from India from the very beginning of its exploitation in the country. During early 1950s our exports varied from 60-80% of total production, but they declined sharply to as low as 15% in 1963. In later years there is improvement and presently it is maintained at about 50% of the domestic production.

Long Term Projections

Viewing for our future requirements of increased steel out-put, as well as refractory and chemical

TABLE 1.12—PRODUCTION, DOMESTIC CONSUMPTION AND EXPORT OF CHROMITE IN TONNES

Year	Production	Export	Domestic consumption			
			Total	Refractory	Chemical	Metallurgical
1964	34,696	31,066				
1965	65,736	33,362	32,374	21,193	7,058	4,123
1966	78,757	43,736	35,021	25,512	7,598	1,911
1967	1,13,868	77,211	33,652	26,512	6,972	168
1968	2,05,675	1,08,222	42,260	38,000	N.A.	4,260
1969	2,26,568	1,11,620	65,000	N.A.	N.A.	15,600
1970	2,73,697	1,53,402	90,050	40,000 (app)	10,000 (app)	40,050
1971	2,73,060	74,024				
1972	2,94,500	1,10,410				
1973	2,77,224	2,21,243				
1974	3,96,535	3,34,005				
1975	5,00,294	3,59,380				

industries, the projected demands of chromite for the above industries from 1975-2000, worked out (by O. P. Varma and Jaypuriar) are given in Table 1.13.

TABLE 1.13—PROJECTED INTERNAL DEMANDS OF CHROMITE (IN TONNES)

Year	Metallurgy	Refractory	Chemical	Total
1975	91,800	45,000	15,000	1,51,800
1980	1,42,500	60,000	20,000	2,22,500
1990	2,25,000	90,000	40,000	3,55,000
2000	3,00,000	1,20,000	80,000	5,00,000

Resource and Gap

Even at the present rate of production of 0.50 million tonnes per year to meet our internal consumption and export commitments our proved reserves of 2.35 million tonnes of chromite might exhaust by early 1980's, due to growing demand. Hence it is imperative that proper steps are taken to prove more tonnages of ore to fulfill our demand upto the end of the century. Presence of new deposits of chromite has already been indicated by preliminary prospecting etc. Intensification of exploration will have to be done to locate potential reserves both in known and unknown areas.

(4) VANADIUM AND TITANIUM ORES

Vanadium is a minor metal that toughens and imports strength to tool steel, high speed steel and automobile industry etc. where strain is involved. It is also added to Cr, Mo, and tungsten steels and in the electrical, chemical, ceramic, paint, dye, and printing industries.

Reserves and Occurrence

Occurrance of Vanadium bearing ores have been reported from a number of localities in India, of which the titaniferous vanadiferous magnetite deposits of Orissa are the most important sources of vanadium presently. Vanadium-bearing titaniferous magnetite has been reported (V% = 1.1%) in Singhbhum district of Bihar. The deposits of Kumardhubi in Mayurbhanj district, Orissa, are considered to be the largest. Vanadiferous magnetite deposits are present near Nausahi etc. in Keonjahar district, Orissa, where V_2O_5% is reported to be between 0.92% to 1.48%. Vanadium is said to be present in the form of coulsonite (FeO V_2O_3) mineral here. Important deposits of titaniferous magnetite also occur in Shimoga, Tumkur and Hassan districts of Karnataka State. Minor occurrences of Vanadium have also been reported from the green mica in Mahalgaon in Bhandara district of Maharastra, magnetite intrusions in Khondalites in Chintalapadu area, Krishna district, Andhra Pradesh with 1% V_2O_5 content. Another source of Vanadium is in the sludge of the aluminium works reported to contain 0.1% V left behind in the bauxite treatment to alumina. The total reserves according to GSI of Vanadiferous magnetite are placed at 15.066 million tonnes (Table 1.14).

TABLE 1.14—RESERVES OF VANADIFEROUS ORE IN INDIA AS ON 1-1-1976. (IN MILLION TONNES)

State	Measured	Indicated	Inferred	Total	Grade
1. *Orissa :—* Mayurbhanj, Keonjhar, Balasore Districts	2.15	—	4.44	6.59	V_2O_5 from 0.5 to 1.8
2. *Bihar :—* Singhbhum dist.		—	1.118	1.118	1.8% V_2O_5 0.56 to 4.12%
3. *Karnataka :—* Hassan, Shimoga Dt. Also in North Kanara Dist.	0.355	—	7.003	7.358	
All India	2.505	—	12.561	15.066	

Specifications and Domestic Consumption

Vanadium is used in the alloy and special steel as ferro-vanadium or vanadium-pentoxide. Vanadium steels containing metals like Cr, Ni, Mo, Mn etc. have different uses including the manufacture of ordnance and armour plates in defence industries. V_2O_5 is used as a catalyst in the synthesis of ammonia and as a substitute for platinum in the manufacture of sulphuric acid.

All our demands which are mostly for defence purpcses are met by import.

Future Outlook

In view of the importance of vanadium in the manufacture of special steels mostly for defence requirements it is imperative that exploitation of vanadiferous magnetite should be augmented and the production of ferro-vanadium etc. in the country be boosted.

(5) ILMENITE AND RUTILE

Ilmenite and Rutile are the two important titanium bearing minerals from which all the titanium metal and the widely used "titania white" pigment are derived. They are very commonly known to occur together in beach sands of our coasts. Titanium metal which is light and tough is widely used in the aeronautic industry, viz. in the aeroframes, jet engines etc. Titanium is also present in the form of titaniferous magnetite in Hassan dt. (Nuggihalli Schist belt) and Shimoga dist. of Karnataka, Dhalbhum-Kumardhubi area of Bihar-Orissa, Khursipar area of Maharastra and in our laterite and bauxite deposits which are said to contain upto 10% Ti.

Reserves and Occurrence

Ilmenite occurs as extensive beach sand deposits in the coastal areas of Andhra Pradesh, Kerala, Tamilnadu, Maharastra and Orissa.

Rutile occurs with or without Ilmenite in the beach sands of Quilon in Kerala and Kanyakumari districts, Tamil Nadu, Ratnagiri Coast of Maharastra and Wheeler Island off Orissa Coast.

The reserves of Ilmenite as estimated by the Department of Atomic Energy are to the tune of 110 million tonnes of varying grades. It was estimated in 1956-57 the reserves of Ilmenite, Rutile and Monazite at 17,530,680, 1,274,170, and 121,300 tonnes respectively over an area of 405 hectares (1000 acres) calculated for a maximum depth of 7.62 m (25 ft.) between Nindakarai and Kayankulam in the beach sands of Quilon district, Kerala.

Production, Specifications and Consumption

The production of ilmenite and rutile are given in Table 1.15. A little of the ilmenite produced is domestically used for the production of white pogment, metallurgical industry (ferro-titanium and titanium metal), chemical industry for the manufacture of titanium compounds and for coating melting electrodes. A bulk of the ilmenite is being exported. Rutile is mainly used in arc-welding electrode industry followed by paints and ceramics. The domestic consumption of ilmenite and rutile is given in Table 1.16.

TABLE 1.15—PRODUCTION OF ILMENITE AND RUTILE (IN TONNES)

Year	Ilmenite	Rutile
1963	25,963	1,871
1964	12,041	1,871
1965	30,062	1,317
1966	30,163	1,816
1967	41,838	2,534
1968	58,000	2,686
1969	47,000	2,499

(*Source :* I.B.M.)

The I.S.I. has formulated the specifications for titanium dioxide for paints vide IS : 411-1953 according to which TiO_2 content in anatase and rutile varieties should be 96% and 94% minimum respectively. The indigenous arc-welding electrode industry prefers rutile containing 95% TiO_2 (Min) with 1% Fe_2O_3 (Max.).

Export and Future outlook

Export of rutile is not normally allowed. Ilmenite is exported to different countries and given in Table 1.17.

More ilmenite can be exported to the East European Market. With the expanding iron and steel and alloy and tool steels as well as the

TABLE 1.16—CONSUMPTION OF ILMENITE AND RUTILE (IN TONNES)

Industry	Ilmenite		Industry	Rutile	
	1966	1967		1966	1967
Titania Pigment	8,050	6,750	Electrode	2,114	2,078
Ferro-titanium	6	2	Paint	458	486
Electrode	26	15	Ceramic	1	N.A.
Total	8,082	6,767	Total	2,573	2,564

(*Source* : I.B.M.)

TABLE 1.17—EXPORT OF ILMENITE IN TONNES

Year	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Quantity	76,456	26,521	15,095	32,076	20,938	48,526	74,005	54,056	50,358	78,070	75,055	118,634

(*Source* : I.B.M.)

air-craft industries the internal demand for ilmenite as well as rutile in the arc-welding industry will be on the increase in the coming years.

(6) NICKEL AND COBALT ORES

Nickel is preeminently an alloy metal and is chiefly used for alloying with other elements like Cu, Cr, Al, Pb, Co, etc. Nickel alloys are used in automobiles, aeronautics, shipping, mining, milling, pressing and other equipments. It is also used for coinage and electro-plating.

Traces of cobalt minerals are recorded in different states. There is no domestic output of cobalt in India and is being imported to meet the requirements.

Reserves

A number of nickelliferrous ore occurrances have been reported throughout the country out of which very few have been classed as of any commercial importance and are now being explcred and exploited. Thus nickel mineral found in association with copper ores of Singhbhum district (Rakha and Jaduguda Mines) in Bihar State and the nickeliferrous laterite deposits of Sukinda and adjoining areas of Cuttack district in Orissa State fall under this category.

According to I.B.M. 7.9 million tonnes of nickeliferrous ochres in the chromite deposits at Saruabil, Sukranghee and Sukinda in Cuttack district, Orissa have been estimated earlier. The G.S.I. estimated a probable reserve of 10.6 million tonnes of nickel ore with 1% Ni in Kansa East Block in Sukinda, and 4.41 million tonnes with 0.8% to 1.0% Ni in Kansa East, North and West Blocks, and a recent estimate of Kansa area stands at 35 million tonnes. The Sukinda and Kansa belt lateritic nickel ore deposits are believed to be of about 100 million tonnes of 0.8% Nickel grade. A public sector corporation M/s. Nickel India (Ltd), has been set up to work these deposits with a production target of nickel powder —4,800 tonnes, and Cobalt powder —200 tonnes and Ammonia Sulphate 17,000 tonnes (by-product) per annum. Pilot Plant test work on the Sukinda nickel ore is taken up at the National Metallurgical Laboratory, Jamshedpur, which would be further translated into a full-pledged commercial plant under M/s. Nickel India Ltd., to be established at a suitable place in Cuttack district in course of time.

The recovery of nickel during the electrolytic refining of copper at Ghatsila, Bihar under M/s. Hindustan Copper Ltd., has been commissioned. The various occurrences of nickel ore are given as follows :—

(1) Andaman islands — North and Middle Andaman — with ultrabasic soil mantle.

(2) Assam — Vicinity of Potin village and north of Ranga valley — Nickel mineral along with Pyrrhotite, chalcopyrite as specks. Ni=0.50%.
(3) Andhra Pradesh — Agnigundala area, Guntur district along with lead deposits. Co=50 PPM — 1.24%, Ni=50−2700 PPM.
(4) Bihar-Singhbhum district in Rakha Mines Ni=0.05% and Jaduguda Mines Ni=0.2%.
(5) Madhya Pradesh — Surguja district — along with zinc mineralisation Co and Ni=50 PPM.
(6) Karnataka — Holanarasipur area, Hassan district — Ni=800 PPM Cu=50 PPM; Co=25 PPM.
(7) Orissa — Cuttack district — Sukinda and adjoining areas — as enrichment of limonite and serpentinous rocks with nickel under laterite — detailed exploration, drilling etc. by G.S.I. indicated 14 million tonnes of nickel ore or 0.8%, 1.0% Ni-grade. This is now presently taken up for commercial production by Central Government, after pilot plant testing programmes at N.M.L.

Sargepalli—Sundergarh district—along with lead deposit Ni—40-65 PPM.

(8) In Rajasthan — in Jhunjhunu district Khetri area along with copper ores as nickeliferous pyrrhotite; in Udaipur district in Rikhabder area in ultrabasic rocks as nickel bearing serpentinites with Ni=1000 PPM.

A recent estimate of Nickel ore (October 1976) is put at 78 million tonnes.

Demand and Import

All the nickel requirements in India are met with so far by imports and given Table 1.18.

Future outlook

The domestic demand for nickel is assessed at 6,000 tonnes and 6,500 tonnes per annum by 1975-76 and 1980-81 respectively. The country's nickel resources can be considered as quite potential with the recent findings of Sukinda deposits (likely about 100 million tonnes of 0.8%) and a part of domestic demand is likely to be met during the next ten years. Further to augment the reserves of nickeliferrous ores it is necessary to study all the laterite cappings present on all the ultrabasic rocks in the country. Further detailed exploration programme is to be carried out of the known deposits to prove their economic viability.

TABLE 1.18—IMPORT OF NICKEL AND ITS ALLOYS IN TONNES

Year	1968	1969	1970	1971	1972	1973	1974
Quantity	2,241	2,483	3,064	3,286	2,498	2,922	4,115

(*Source:* I.B.M.)