CHAPTER 2

Indian Iron Ore Resources & Exploitation

India is bestowed with large resource of iron ore. Iron ore occurs in different geological formations. However, major economic deposits of iron ore are found associated with volcano-sedimentary Banded Iron Formation (BIF) of Precambrian age.

Hematite and magnetite are the most prominent of the iron ores found in India. Of these, hematite is considered to be the most important iron ore because of its high grade quality & lumpy nature, which is consumed by a large number of steel & sponge iron industries in the country.

As per United Nations Framework Classification (UNFC) of mineral resources, total resources of iron ore in the country is around 28.52 billion tonnes (National Mineral Inventory) as on 1.4.2010. Hematite and magnetite are the principal ores of iron. Of the estimated 17.88 billion tonnes of hematite available, 8.09 billion tonnes are under 'reserve' category and 9.79 billion tonnes under 'remaining resource' category. Whereas total resources of magnetite are estimated at 10.64 billion tonnes of which reserves are merely 0.02 billion tonnes while 10.62 billion tonnes are remaining resources (Fig.-2)

Almost the entire present-day production of iron & its products comes from hematite reserves, magnetite reserves are not being exploited as these are mostly in eco-fragile areas of the Western Ghats. Therefore, these reserves (magnetite) would remain locked up for the next decade till these can be considered for exploitation through special mining methods, which take care of environmental issues satisfactorily.

Around 96% of hematite resources are confined in the States of Orissa, Jharkhand, Chhattisgarh, Karnataka and Goa. The remaining resources are spread in the States of Maharashtra, Madhya Pradesh, Uttar Pradesh, Rajasthan, Assam etc. The statewise reserves and remaining resources as per NMI as on 1.4.2010 are presented in Figs -3 & 4.

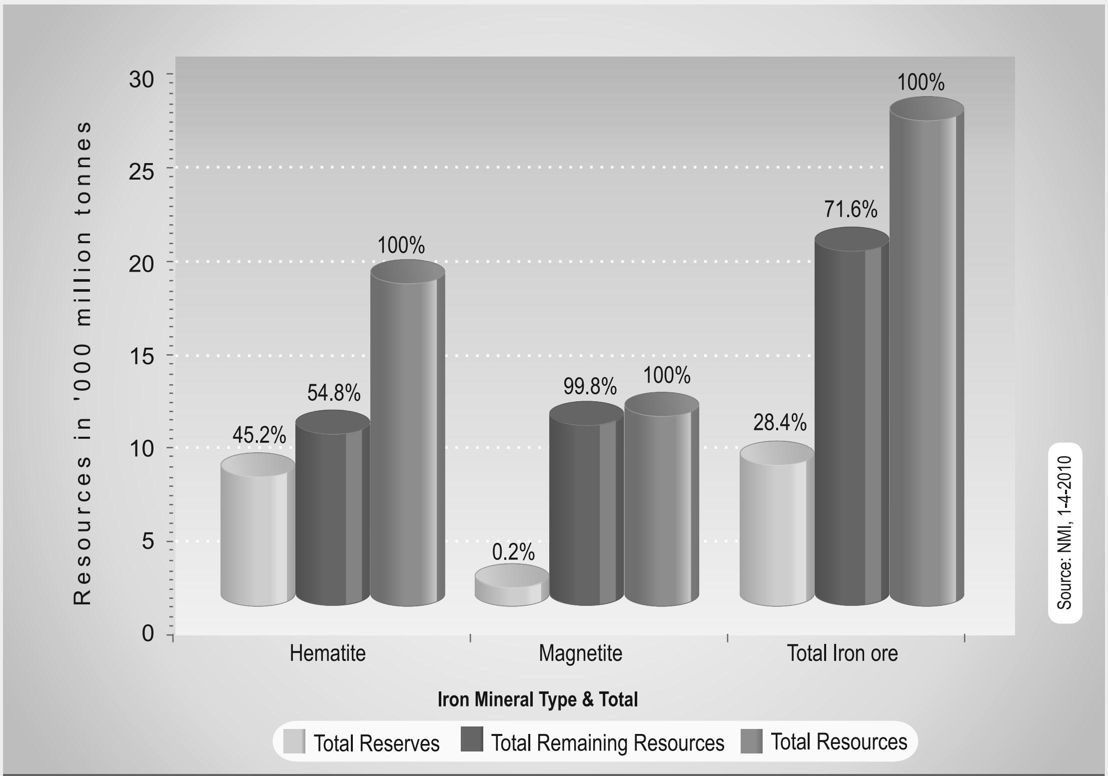


Fig.-2: Total Resources of Iron Ore in India as on 1.4.2010

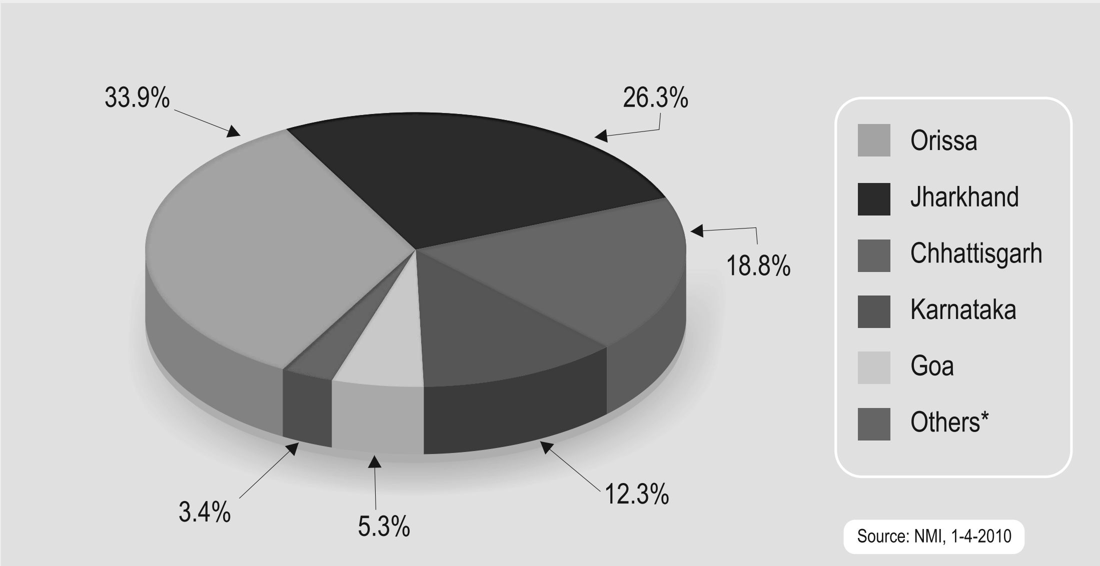


Fig.-3: Statewise Total Resources of Hematite Iron Ore as on 1.4.2010

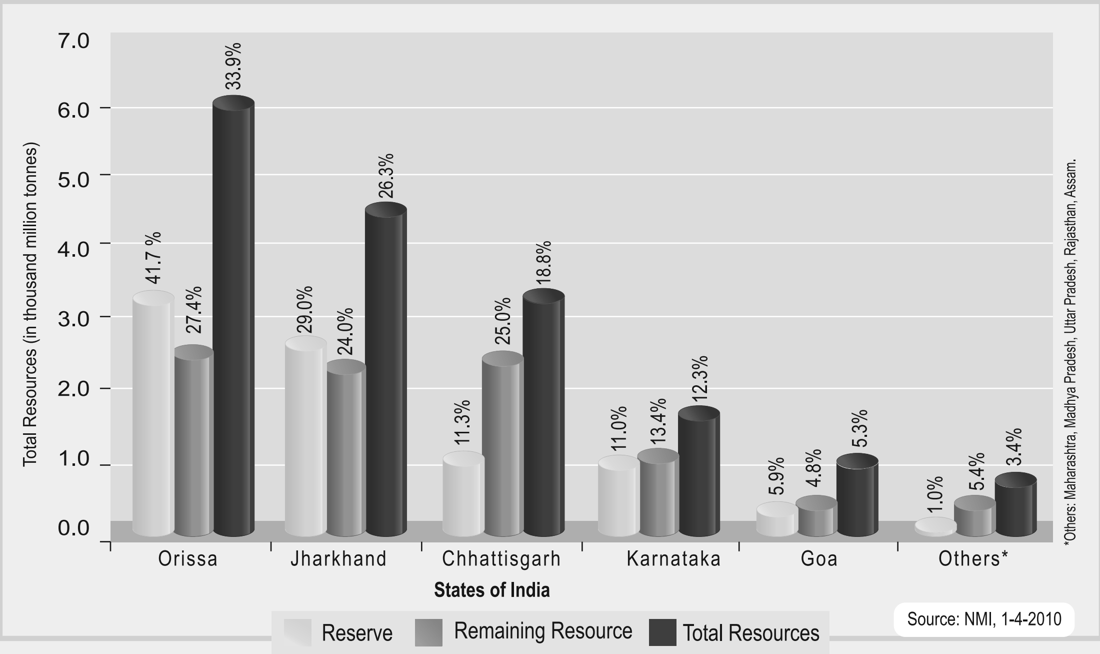


Fig.-4: Statewise Reserves & Total Remaining Resources of Hematite Iron Ore

Existing reserves of hematite merely accounts for around 28% of the total iron resource of the country (28.52 billion tonnes). In India, around 70% of the hematite reserves and 50% of the total remaining resources (Total Resources 60%) are located in the States of Orissa & Jharkhand only while, Chhattisgarh and Karnataka account for around 11% each of the hematite reserves and around 40% of total remaining resources.

The hematite reserves of 8093 million tonnes comprise 73.9% (5982 million tonnes) of measured reserve (code-111) and remaining is under probable reserve (code-121&122). This categorisation of total reserve is presented in Fig.-5.

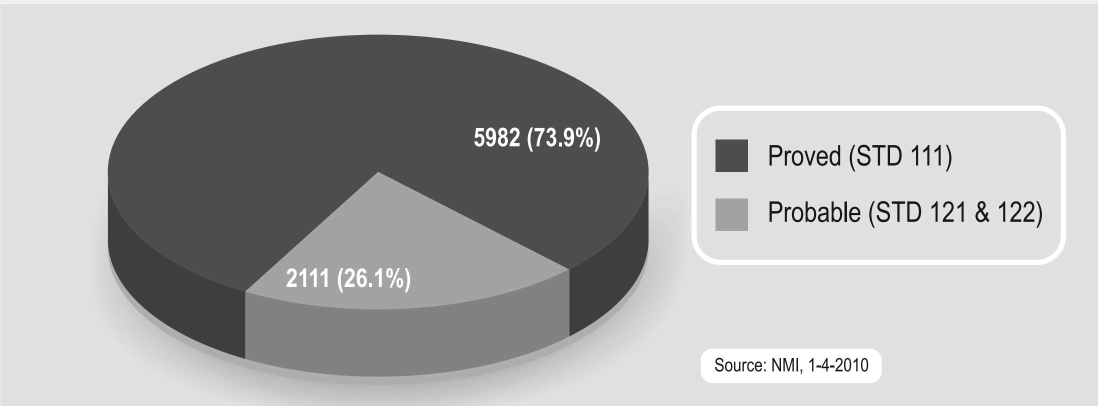


Fig.-5: Categorisation of Hematite Reserves in India (in million tonnes)

Majority (over 85%) of the hematite ore reserves are of medium to high-grade (+62% Fe) and are directly used in blast furnace & DRI plants in the form of sized lumps or sinters or pellets. Gradewise share of hematite in India is presented in Fig.-6.

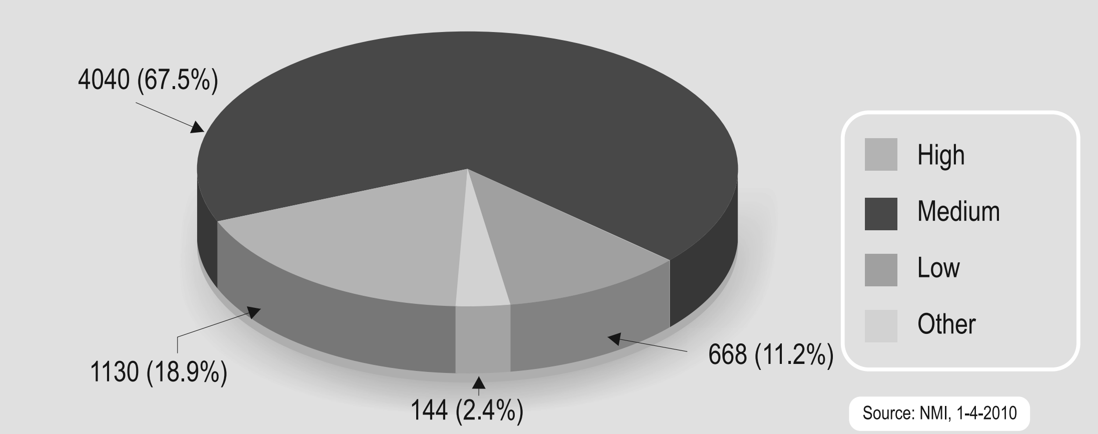


Fig.-6: Gradewise Share of Hematite Reserves in India (in million tonnes)

A close look at the gradewise share of hematite reserves in the country will reveal that a cut-off grade of +60% Fe has only been taken for exploration programme as against present threshold of 45% Fe and hence reserve estimates were on much lower side.

The remaining hematite resources of 9788 million tonnes fall predominantly (around 65%) under Inferred (STD 333) and Reconnaissance (STD 334) category, while Feasibility (STD 211) and Pre-feasibility (STD 221 & 222) category account for a mere 10% only. The present categorisation of total remaining resources as per NMI (1.4.2010) is presented in Fig.-7.

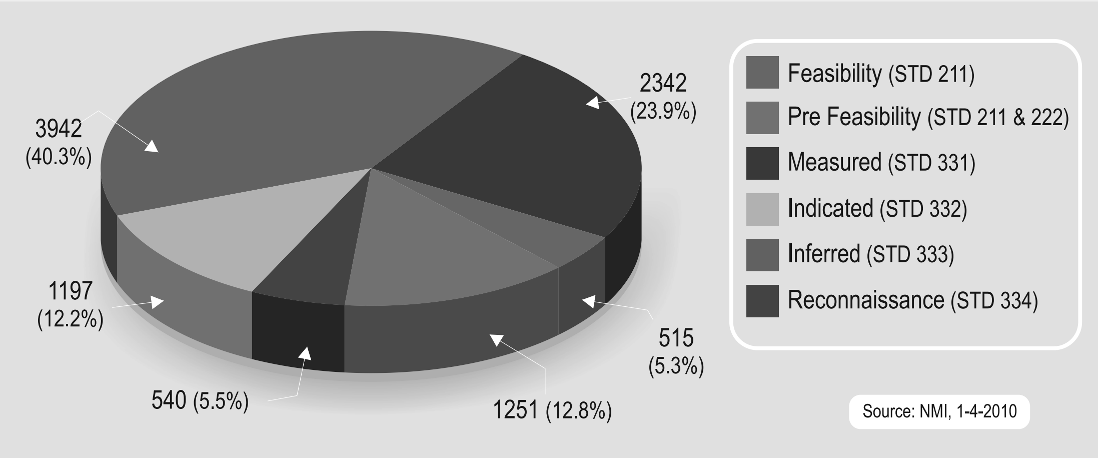


Fig.-7: Categorisation of Total Remaining Resources of Hematite in India (in million tonnes)

2.1. GENERAL GEOLOGY

Iron ore occurs in different geological formations in India, but the most important deposits of economic importance belong to the pre-Cambrian Age. The geological setting of Indian iron ore formations, together with the nature of ores and the regions in which the important deposits occur are shown in Table-1.

2.1.1 Iron Ore Formations

2.1.1.1 Pre-Cambrian: The most important iron ore deposits of India are those associated with the banded hematite jasper/quartzite of the Dharwarian formations of South India and their equivalents of the iron ore series found in Northern India. The ores are derived from the enrichment of banded ferruginous rocks by the removal of silica. The ore body generally forms the tops of the ridges and hillocks, which are often of great magnitude. Most of them contain high-grade ores near the surface, with an iron content of over 60% and are associated with even larger quantities of low-grade ores. Where metamorphosed, regionally or by igneous intrusive, these banded hematite jaspers have been converted into banded quartzite magnetite rocks, which also attain considerable importance in certain areas in Tamil Nadu and in Southern Karnataka. These ores are of low-grade, as they occur, containing only about 35 to 40% iron, but are amenable to concentration after crushing to a suitable size. At some places in Singhbhum and Mayurbhanj districts, titaniferous magnetite bodies are associated with basic and ultra-basic intrusives. These deposits are considered to be of ortho-magmatic origin.

Geographically, the Pre-Cambrian banded iron ore formations are distributed in five broad belts/zones, wherefrom, hematite – a high-grade iron enriched ore – is the principal ore mined for iron & steel making in the country.

Zone A	Singhbhum in Jharkhand and Cuttack in Orissa
Zone B	Dantewara & Durg in Chhattisgarh and Chandrapur & Gadchiroli in Maharashtra
Zone C	Bellary-Hospet belt in Karnataka
Zone D	Goa, Ratnagiri in Maharashtra and North Karnataka.
Zone E	Metamorphosed BIF along the West coast in Karnataka and Kerala

Table-1 Geological Setting of Indian Iron Ore Formations

Formation		Nature of Ore	Occurrence
Quaternary		Laterite	Many States—derived from many formations including Deccan Traps
Tertiary	Miocene & Eocene	Ironstones	South India—Travancore, Malabar, etc.; Assam—NE districts; U.P.—Kumaon
Jurassic	Rajmahal Trap (intertrapean beds)	Ironstones	West Bengal; Bihar—Rajmahal, Birbhum
Gondwana	Barakar Mahadeva Ironstone shale Triassic	Ironstones & siderite Siderite Ironstone & siderite Hematite and goethite	West Bengal—Birbhum; Bihar—Auranga Coalfield; West Bengal—Ranjganj Coalfield; Kashmir
Cuddapah	Bijawar Gwalior	Hematite and ferruginous Quartzite	Madhya Pradesh—Gwalior, Indore, etc.; Andhra Pradesh—Cuddapah
	Basic & ultra' basic Rock	Titaniferous & Vanadiferous magnetite's	Bihar—S E Singhbhum; Orissa—Mayurbhanj
	Granodiorite	Apatite-magnetite rocks	Singhbhum
	Granite	Magnetites (residual)	Assam—Jaintia Hills; Karnataka—Kudremukh
Pre-Cambrian	Banded Iron Formation (BIF)	Hematite Massive Shaly, powdery, etc.	Orissa—Sundergarh, Keonjhar, Mayurbhanj; Kamataka—Shimoga, Bellary-Hospet, Dharwar, etc.; Bihar—Singhbhum (West); Maharashtra—Ratnagiri,Chandrapur; Madhya Pradesh—Bastar (Bailadila), Durg, Jabalpur
	Banded Iron Formation (metamorphosed)	Magnetite-quartzite	Tamil Nadu—Salem, Tiruchirapalli; A.P.—Guntur; Karnataka—Shimoga, Chikmagalur; Himachal Pradesh—Mandi

2.1.1.2 Cuddapah: The Bijawars of Central India and the Pulivendla quartzites of Cuddapah district in Andhra Pradesh contain workable deposits of rather small size. They seem to be locally enriched portions of ferruginous formations.

2.1.1.3 Vindhyan: No useful deposits are known in these formations though some sandstone is to some extent ferruginous. Occasional pockets and concretions of limonite are associated.

2.1.1.4 Gondwanas: The Barakar formations in rare instances contain concretionary masses of limonite. In the Auranga Coalfield in Bihar, clay-iron stones are found in these formations. Some of these deposits appear to have been derived from the original carbonate ore by oxidation and hydration. The ironstone shale stage, particularly of Raniganj Coalfield, contains considerable amount of clay. Ironstone derived from siderite is irregularly distributed as thin lenses in the formation. At some places, iron ore lenses and concretions are reported to form 5 to 7% volume of strata. In the succeeding Raniganj-Kamthi group, there is much disseminated iron to produce the prevailing red tints in the sandstones, but nowhere sufficient concentration of the material to constitute workable ore is found.

2.1.1.5 Jurassics: The inter-trappean beds of Rajmahal Hills contain thin beds and concretions of ironstone which were formerly worked for smelting in small indigenous furnaces.

2.1.1.6 Deccan Traps: The tropical weathering of Deccan traps at and near the surface has given rise to massive beds of laterite which at many places is fairly rich in iron, averaging 25 to 30% of the metal. The laterite also contains deposits of titaniferous bauxite. They are likely to assume importance in future when attention is focused on lower grade ores. Laterite also occurs over gneissic rocks in Malabar and Travancore and over the Rajmahal Traps in Bihar. The limonitic materials from laterite, often forming rich concretions, were won and smelted by indigenous artisans for many centuries. At present, however, they are of little value as ores, the rich hematite ores of the Pre-Cambrian formations are available in abundance and are preferred.

2.1.1.7 Tertiary: The Nahan series of Siwaliks in Uttar Pradesh and Assam-Himalayas, the Tipam series of Upper Assam and the Rajahmundry, Cuddalore and Varkala sandstones of Tamil Nadu and Kerala, all contain fairly rich concretions of ironstone which were formerly used as ore in the respective regions. They belong to the Miocene–Pliocene Age.

2.1.2 MINERALOGY

Commercially, iron is a very important metal. It is found in the form of chemical compounds with other elements in a number of minerals. Natural occurrences of iron ore are abundant all over the world. Iron ore occurs most abundantly in the form of oxides. Other forms are carbonates, hydroxides, sulphides and silicates. It is also found in association with titanium dioxide.

Commercially, the most important minerals of iron are in the form of oxides, i.e., hematite (Fe_2O_3) and magnetite (Fe_3O_4). A list of common iron-bearing minerals and its properties are furnished in Table-2.

Mineral	Composition	Iron Content (%Fe)	Specific Gravity	Hardness (Moh's Scale)	Colour
		OXIDES			
Hematite (Alpha) and Martite	Alpha-Fe_2O_3 (Hematite pseudomorphous after magnetite)	70	4.9-5.3	5.5-6.5	Steel grey to red
Turgite	2 $Fe_2O_3.H_2O$	66.1	4.2-4.6	6.5	Brown to red
Goethite	$Fe_2O_3.H_2O$	62.9	3.4-4.2	5-5.5	Brown to red Brown to yellow
Limonite	2 $Fe_2O_3.H_2O$	60	3.4-4.2	5-5.5	
Lepidocrosite	$Fe_2O_3.H_2O$	62	4.09	5	Brown to reddish brown
Ilmenite	$FeTiO_2$	36.8	4.5	5-6	Black to brownish black
Maghemite	Gamma-Fe_2O_3	69.9	4.88	5	Brown
Magnetite	Fe_3O_4	72.4	5.17	5.5-6.5	Black, blue or brown black
		CARBONATES			
Siderite	$FeCO_3$	48.2	3.7-3.9	3.5-4.5	Ash grey to brown
		SULPHIDES			
Pyrite	FeS_2	46.6	4.8-5.1	6-6.5	Brass yellow
Marcasite	FeS_2	46.6	4.9	6-6.5	Light brass yellow
Pyrrhotite	FeS_2	61.6	4.4-4.65	3.5-4.5	Bronze yellow
		SILICATES			
Chamosite	$(Mg.Fe.Al)_6$ $(Si.Al)_4O1_4(OH)_8$	33.42	3-3.5	3	Green to light yellow

Table-2: Common Iron-bearing Minerals & its properties

Hematite is the most abundant iron ore mineral and is the main constituent of the iron ore industry in India. It occurs in a variety of geological conditions throughout the World. It is the red oxide crystallising in hexagonal system. The fine-grained hematite is deep red, bluish red, or brownish red and may be soft and earthy ocherous, compact or highly porous to friable, or granular, or may be in the form of dense hard lumps. Considerable siliceous or argillaceous impurities are common. The coarse crystalline hematite is steel grey with bright metallic to dull grey lustre. The coarse grain hematite is known as specularite or specular hematite and may form blocky or platy crystals with a strong micaceous parting. The composition of hematite is Fe_2O_3. Ideally, it contains 69.94% Fe and 30.06% oxygen. The specific gravity varies from 4.9 to 5.3 (when pure) but in natural occurrence it generally has less specific gravity. The hardness varies from 5.5 to 6.5 for hard ore and is much less for softer varieties. Hematite is feebly magnetic although in practice it has shown wide range of magnetic susceptibility (2000 to 20,000 gauss).

2.2. DISTRIBUTION OF IRON ORE IN INDIA

The iron ore deposits of India can be broadly divided in to the following six groups on the basis of mode of occurrence and origin:

1. Banded Iron Formations (BIF) of Pre-Cambrian Age
2. Sedimentary Iron Ore Deposits of Siderite and Limonitic Composition
3. Lateritic Ores derived from the Sub-Aerial Alterations
4. Apatite-Magnetite Rocks of Singhbhum Copper belt
5. Titaniferous and Vanadiferous Magnetites
6. Fault and Fissure Filling Deposits

In India, major economic deposits of iron ore are found associated with volcano-sedimentary Banded Iron Formation (BIF) of Pre-Cambrian Age. The major "hematite" type iron deposits are located in well defined belts in the States of Orissa, Jharkhand, Chhattisgarh, Maharashtra, Goa and Karnataka (Fig.-8). Minor deposits are located in Andhra Pradesh, Madhya Pradesh and Assam. Zonal Distribution of Iron ore in India is presented in Table-3, wherein first four zones (A to D) accounted for hematite mineralisation while, Zone E contains predominantly magnetite.

Extensive outcrops of BIF are found in the States of Jharkhand, Bihar, Orissa, Madhya Pradesh, Chhattisgarh, Maharashtra, Karnataka, Goa and Tamil Nadu. The most common names used in India to designate BIF are Banded Hematite Quartzite (BHQ) and Banded Magnetite Quartzite (BMQ). In Jharkhand and Orissa, the names like Iron-ore series and Iron-ore group are used as stratigraphic names.

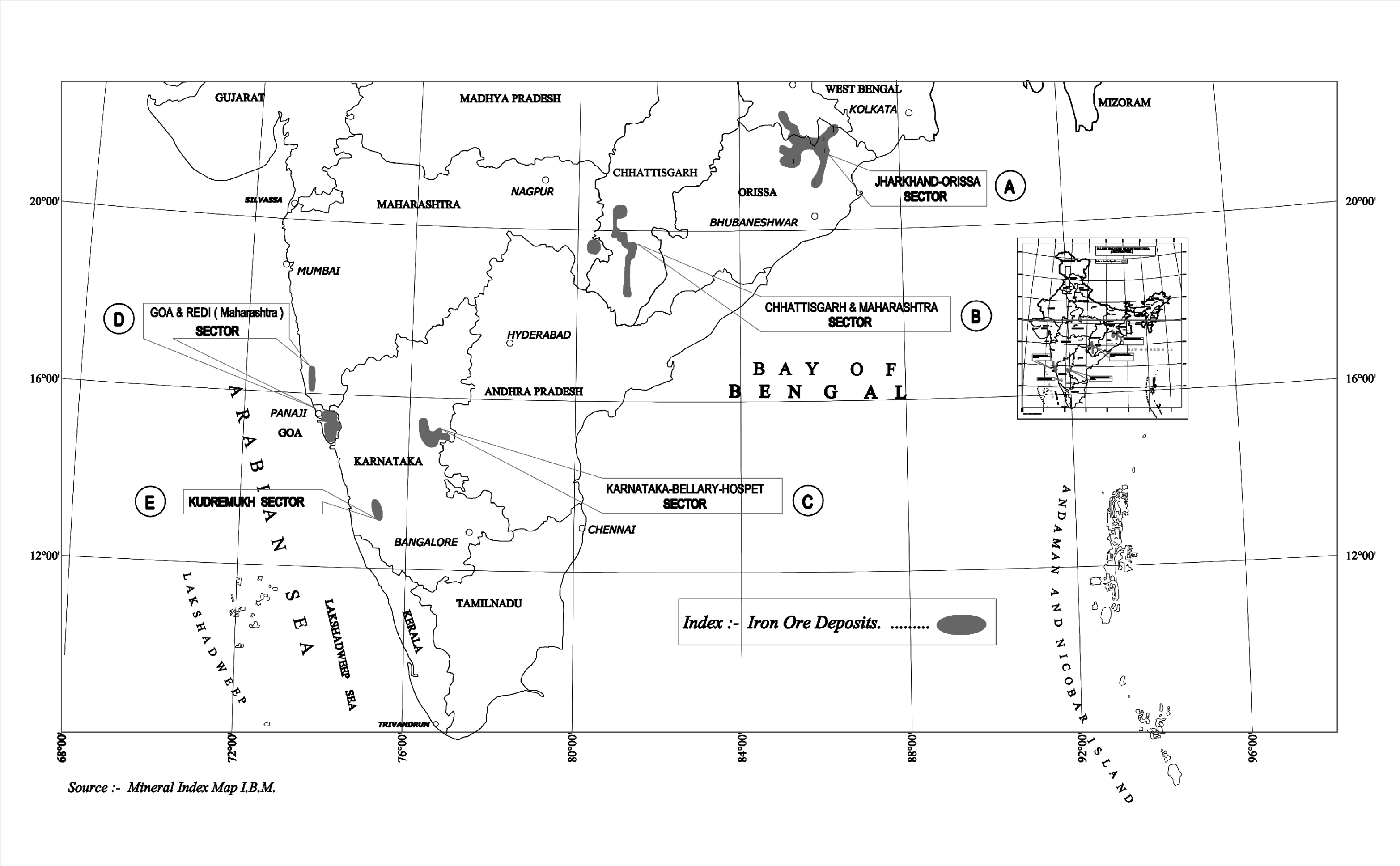


Fig. 8 : Major Iron Ore Deposits of India (Zonewise / Sectorwise

Table-3: Zonewise Characterisation of Indian Iron ore		
Zone	**Locations**	**Nature of mineralisation & Mineral assemblages**
A .	**Bonai Iron ore ranges in Jharkhand & Orissa and in adjoining areas in eastern India** (Chiria, Noamundi, Kiriburu, Meghatuburu, Thakurani, Gua, Taldih, Bolani, Joda, Daitari, Khondbond,Gandhamardan etc.)	They are in BHQ/BHJ formations and occur as massive ore (58-66% Fe), laminated ore, shaly ore, blue dust (66-68% Fe) & lateritic ores (56-60% Fe). In all these formations, hematite occur intimately associated with limonite & goethite. Lateritic ores contain numerous small cavities filled with limonite, goethite & ocherous material.
B.	**N-S trending linear belt in Central India in the States of Chhattisgarh, M.P. & East M.S.** (Bailadila, Dallirajhara, Mahamaya, Aridongri, Rowghat, Surajgarh)	Associated with BHQ. Mainly laminated & massive ore of high-grade hematite (64-68% Fe). Predominantly hard & compact hematite with minor amounts of limonite goethite. Associated gangue minerals are quartz, clay, ferruginous shale etc.
C.	**Bellary-Hospet region of Karnataka** (Donimalai, Ramendurg, etc.)	BHQ/BHJ intercalation of ferruginous shale. Long, narrow & scattered patches of hematite with intervening shale bands containing 58-64% Fe. Hematite with minor amounts of magnetite, martite, specularite & goethite contants quartz & clay as main impurities.
D	**Goa & West Maharashtra** (North & South Goa, Reddi)	Predominantly (~80%) blue dust (63-64% Fe) and fines (59% Fe) with little lumps (57-58% Fe). Goethite/limonite & clay/gibbsite occur with banded ferruginous quartzite & ferruginous phyllite.
D	**Magnetite deposits of Karnataka** (Kudremukh, Bababudan hills, Kodachadri)	Thick bands and lenses of hematite/magnetite in BHQ/BMQ, formations (57-62% Fe). Associated gangue is mainly quartz.

The major ore minerals are hematite and magnetite. Important hematite accumulations are in Singhbhum district (Jharkhand), Keonjhar (Orissa), Bellary (Karnataka), Bastar district (Chhattisgarh) and Goa. Magnetite ore deposits are mainly confined to the Chikmagalur district in Karnataka and Salem and North Arcot districts in Tamil Nadu.

The Banded Iron formation (BIF) of Pre-Cambrian Age has given rise to vast accumulations of commercial grade iron ore deposits in India, more than 90% of the iron ore supplied to the industry comes from BIFs. The various physical types of iron ore which are exploited commercially from banded hematite formations are massive ores, laminated ores, lateritic ore & blue dust. In Indian scenario, the nature of mineralisation of hematite ore, its associated gangue and general chemical analyses of above varieties are presented in Table-4.

Table-4: Mode of Occurrence of Hematite Ore Mineralisation in BIF

Ore Type	Sp. Gr.	%Fe	%SiO_2	%Al_2O_3	Iron Mineral	Gangue Minerals	Nature
Massive	>5.0	64.2-69.0	0.34–4.19	0.55–3.66	Hematite, Goethite, Martite	quartz, clay	Hard & compact
Hard Laminated	4.2–4.7	56.8-66.6	0.81–5.73	1.00–7.14	Hematite, Goethite, Limonite	clay (kaolinite), gibbsite, quartz & chert	Laminated structure hard & compact
Soft Laminated	4.2–4.5	57.0-65.5	1.20–8.60	1.10–11.0	Hematite, Goethite, Limonite	clay, shale, gibbsite, quartz & chert	Laminated structure soft & friable
Lateritic	3.8–4.2	58.8-61.5	1.00–6.88	3.72–8.85	Goethite, Limonite, Hematite, ochre	clayey lateritic materials, gibbsite & silica	Dull lustre, cavernous & friable
Blue Dust	>5.0	65.0-69.0	0.64–2.12	0.35–2.49	Hematite, Goethite,	quartz, clay	Powdery

2.3. STATUS OF EXPLORATION

Most of the iron ore deposits in India were explored in the fifties and sixties when the major Public Sector integrated steel plants came into existence. Keeping in view the then available technological know-hows and demand of the steel plants, exploration agencies laid emphasis on establishing resource of iron ores whose grade were 60–63% Fe. And while doing so, after preliminary classification of the various ore types in particular deposits, zones of lower grades were overlooked and therefore no systematic drilling of such zones nor any analyses of ore samples from such portions of the deposit were undertaken. Only in certain cases in Karnataka and Goa, resources were evaluated for lower grade ores besides the high-grade ores particularly at deposits where low-grade iron ores were generally found associated with high-grade types. Cases of deposits with exclusive low-grade iron ores that were explored were scarce.

The country has huge resources/reserves of low-grade iron ore. Exploration and mining efforts to tap low-grade ores have not been adequate. Fresh exploration strategy to draw ores with +45% Fe grade as a target is on the anvil. Given the current stage of economic development, the need of the hour is not only to explore new deposits but also to make use of low-grade ores. In the context of future availability of iron ore for the domestic industry and also for global business, attention for potential use of low-grade iron ores, especially fines is gaining momentum.

2.4. STATUS OF EXPLOITATION

Most of the larger iron ore belts already explored for high-grade ores have been exploited both for high and medium-grade ores through the last six decades. The low-grade fines, even from operating mines have not been utilised adequately and were treated as waste. The States of Orissa, Karnataka, Chhattisgarh, Goa and Jharkhand are major producers of iron ore in the country. The status of iron ore mining leases in India is presented in Table-5.

Production of iron ore in the country is through a combination of large mechanised mines in both Public and Private Sectors and through several smaller mines operated on manual or semi mechanised basis in the Private Sector. These can be broadly grouped as under:

No. of Leases	Lease Area (In Hectares)
769	94307.86

(As on 31-03-09)

Table-5: Status of Iron Ore Mining Leases in India

2.4.1 Captive Mines

Owned and operated by individual integrated steel plants (ISP's) both in public and private sectors mainly for their own use (i.e. SAIL, TISCO etc.).

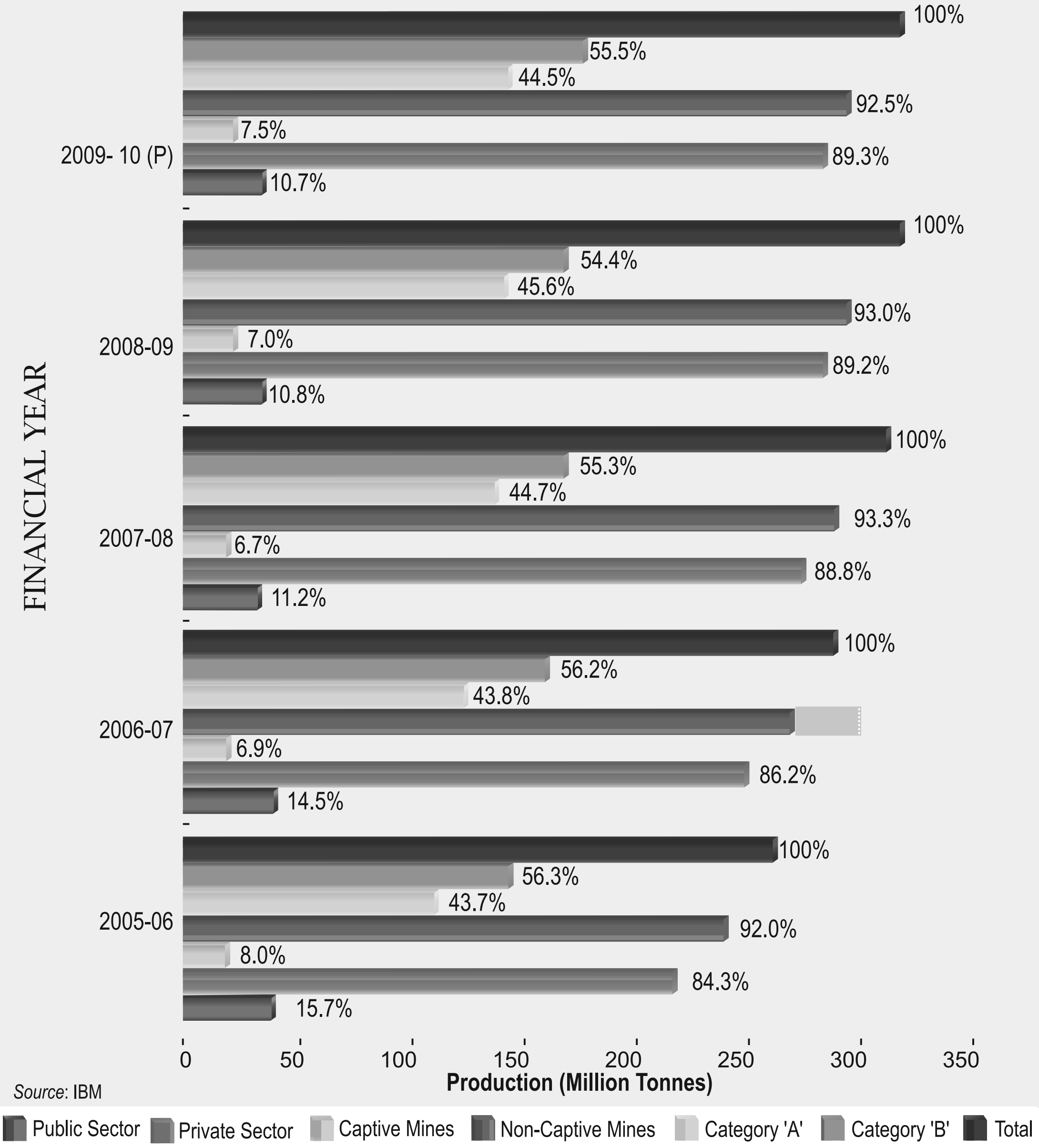
2.4.2 Non-captive Mines

These are merchandise mines both in public and private Sectors operated specifically to meet the demand of DRI units in the country as well as for export.

2.4.2.1 In Public Sector : Undertaking of the Central Govt. or that owned by the Central or State Govt. that have no restriction of captive consumption, viz. National Mineral Development Corporation Ltd (NMDC), Kudremukh Iron Ore Co. Ltd (KIOCL) and the State Government Undertakings, such as, Orissa Mining Corporation (OMC), Mysore Minerals Ltd, (MML) etc. fall under this category.

2.4.2.2 In Private Sector: These mines are operated mainly to meet export demand as well as for internal consumption purposes. The companies, such as, Sesa Goa Ltd, Chowgule & Co. Pvt. Ltd, M/s Mineral Sales Pvt. Ltd, Rungta Mines Private Ltd, Jindal Steel and Power Ltd, etc. fall under this category.

The number of mines that have been reported during the period 2005-06 to 2009-10 in respect of Captive vs. Non-captive, Sectorwise (public vs private) and categorywise ("A" & "B") are presented in Fig-9.



Source: IBM

Fig-9: Iron Ore Mines in India —Sectorwise and Categorywise

2.5. MINING PRACTICES

Normally iron ore mining is carried out by opencast method all over the world. The methods of mining can broadly be classified, on the basis of the level of mechanisation, into three categories:

2.5.1 Manual Mining

Generally manual mining are confined to float ores where mining is being done by digging manually. The mined material is screened manually to separate +10 mm float ore for production. The undersize (-10 mm) is treated as waste and is thrown back into the pits. The cost of mining and output per man shift (OMS) varies from mine to mine. Output per man shift (OMS) is normally 1.5 to 2 tonnes. Manual mines are mainly under Private Sector.

2.5.2 Semi-mechanised Mining

Wherever iron ore occurs in small pockets or lenses of boulder or as segregation in laterite, it is difficult to mechanise the mining operation and in such the deposits semi-mechanised mining method is carried out. In practice, overburden is removed by machines while iron ore is handled manually to minimise wastages.

2.5.3 Mechanised Mining

Over 90% iron ore production in the country comes from mechanised mines. Here mining is done by formation of systematic benches on overburden and orebody. In these mines, the methodology adopted for mining of ore/overburden is by utilising shovel-dumper combination. Mining is invariably carried out by systematic formation of benches by drilling and blasting. The loading operations are also fully mechanised and transportation is facilitated by maintaining mine haul roads. Further, ore handling, washing and screening operations are mechanised. The degree of mechanisation and the size of the machinery vary with the material required to be handled in the mines. Majority of the large mechanised mines are in the Public Sectors. Some mechanised mines in Goa, Jharkhand, Orissa and Karnataka (Bellary-Hospet sector) are also operated by Private players.

In general, mining of iron ore in India is done by developing benches from the top of the hill and is carried downwards as the ore at the top gets exhausted. The methodology generally adopted for winning of iron ore is by shovel–dumper combination in case of major mechanised iron ore mines. The bench height generally adopted in iron ore mines in India ranges from 6 to 14 m and the slope of the benches ranges from 45^0 to 60^0 depending on the consistency/tensile strength of the rock. However, in Goa region where the ore is softer, hydraulic excavator and wheel loaders are the principal loading equipment used and the height of benches is kept restricted between 4 m and 7 m.

The height of the benches that need to be maintained depend on several factors, such as output requirement, shape, size and depth of the orebody, geological disturbances suffered by the orebody, hardness & compactness of orebody, type & size of machinery proposed to be deployed, availability of finances, etc. All are interdependent factors and careful evaluation of these are mandatory.

Except in uniform deposits, the direction of the bench along the strike of the beds encounters different beds of ores as the working face advances, resulting in considerable fluctuations of the grade of ore produced. This could be minimised if many benches are worked simultaneously at different depths. This, in turn, requires a large number of smaller machines which create their own problems of supervision, maintenance, etc. It is therefore, commonly preferred to open-up benches as far as possible across strike of the beds, so that uniform grades of the ore are produced.

The length of the face is also dependent on various factors, such as contours of deposit, output required, variation in grade and blending requirements, capacity of loading machinery, etc. and varies between wide limits from as small as 60 m to as large as 400 m. The width of the bench is governed to a large extent by the size of the largest machinery deployed and varies by approximately three times of the width of the dumper.

As an universal practice, iron ore is dislodged by drilling blastholes according to a particular pattern which depends on the bench height, the hole diameter, the drilling machinery deployed, nature of rock and the types of explosives used. These blastholes are vertical but can be inclined also for obtaining better blasting results. The 310 mm diameter rotary drill is the largest so far being deployed in India. Rotary drill is used normally in the size from 150 to 250 mm. Drilling with 150 mm diameter blastholes has been the common practice in Indian iron ore mines. Probably, this is due to ready availability of indigenous drill machines of the size. But higher rate of production makes the incumbent to adopt greater bench heights and larger diameter holes. The greater bench heights permit the use of large shovels, which in turn can handle larger boulders and permit larger spacing and burdens.

As mechanised opencast iron ore mines are becoming larger, deeper and more capital intensive, continuing efforts are being made to improve upon the opencast mining activities through advances in the equipment size/design and practices and also through introduction of innovative techniques. Significant results have been achieved through increasing size of stripping and hauling units, which apparently has reached a plateau; efforts on further improvements are being spearheaded through new concepts in equipment utilisation by restoring to automation and control. The application of high capacity continuous surface mining techniques to harder formations enabled by new concept of high angle belt conveying system, in-pit crushing systems (mobile and semimobiles), high capacity dumpers, automatic truck dispatch system, non-electric blast initiation systems etc. and developments in the area of bulk explosive systems hold out almost unlimited opportunities for upgrading the performance of opencast iron ore mining in India.

The reserves of high-grade iron ore are limited. Therefore, it would be necessary at this stage to ensure conservation of high-grade ore by blending with low grade ores. R&D efforts are needed for developing necessary technologies for utilising more and more fines in the production of steel as a measure of conservation of iron ores. With the present high capacity of iron ore mines, total utilisation of iron ore has become essential so as to obtain maximum returns. In most of the mechanised mines more than 50 to 60% fines (except for Bailadila and some mines in the eastern zone where the ore is very hard) are generated. Blue dusts in these mines are to be fully utilised to make various value-added products. Blue dust can also be used as additive in concentration of iron ore fines to the extent of 20-40% for use in steel plants.

2.6. PRODUCTION, CONSUMPTION & EXPORT

2.6.1. Iron Ore Production

The production of iron ore since 2005-06 recorded an increasing trend. The production of iron ore which was 165.2 million tonnes in 2005-06 increased to 218.6 million tonnes in 2009-10. Orissa was the major producer followed by Karnataka, Goa, Chhattisgarh and Jharkhand.

The production of iron ore lumps, fines & concentrates in the country and stateswise production of fines & lumps during the period from 2005-06 to 2009-10 is presented in Figs-10 to 12 respectively.

The gradewise iron ore lumps & fines production in India during the period from 2005-06 & 2009-10 is presented in Figs-13 & 14 respectively.

The sectorwise, categorywise and captive/non-captive mine iron ore production in India during the period from 2005-06 to 2009-10 is presented in Figs-15 to 17 respectively.

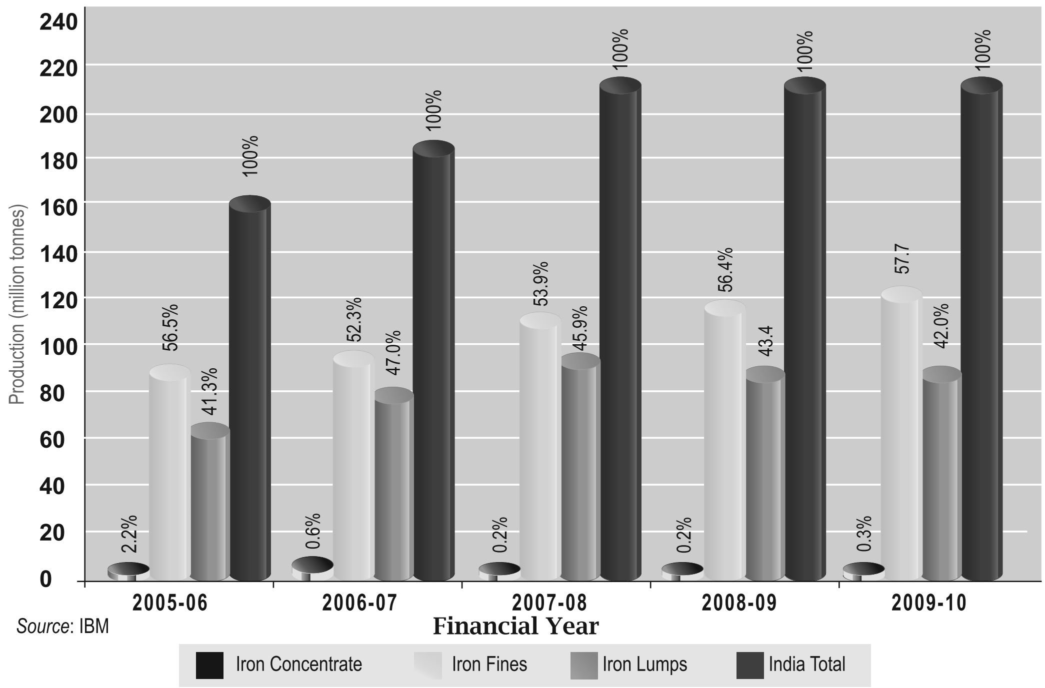


Fig-10: Production of Iron Ore Lumps, Fines & Concentrates in India

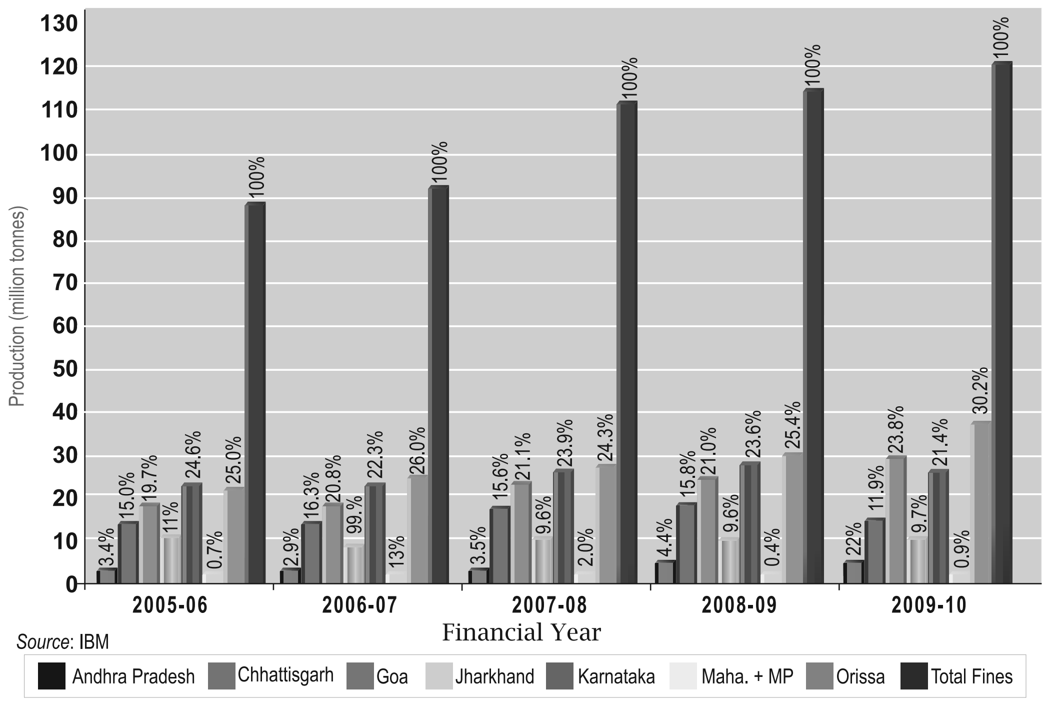


Fig-11: Statewise Production of Iron Ore Fines in India

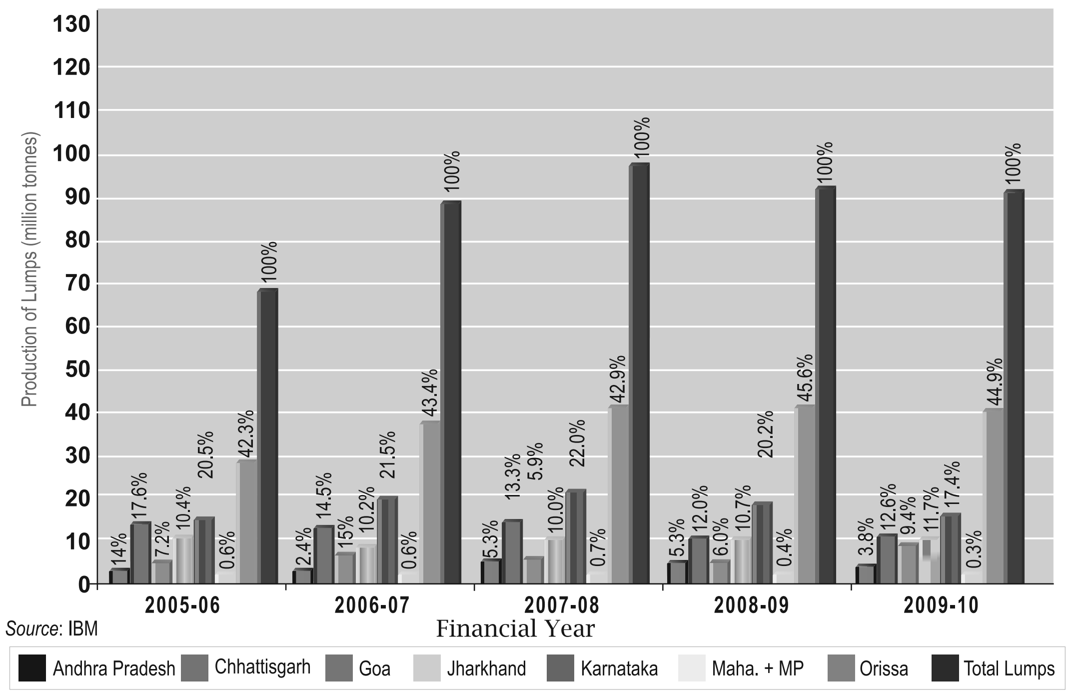


Fig-12: Statewise Production of Iron Ore Lumps in India

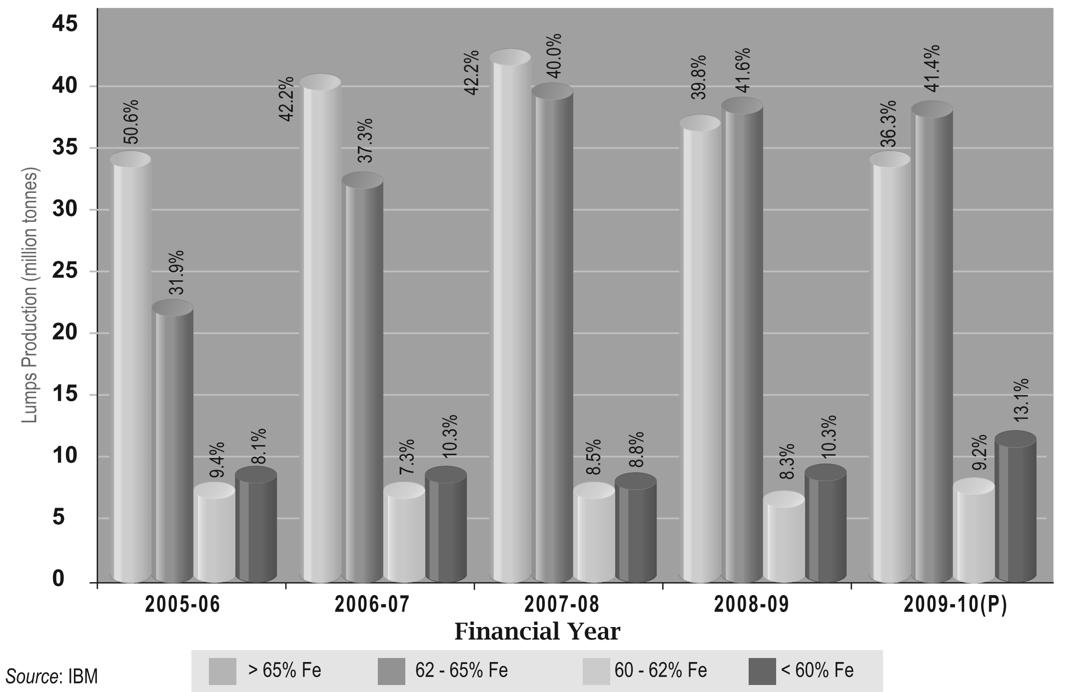
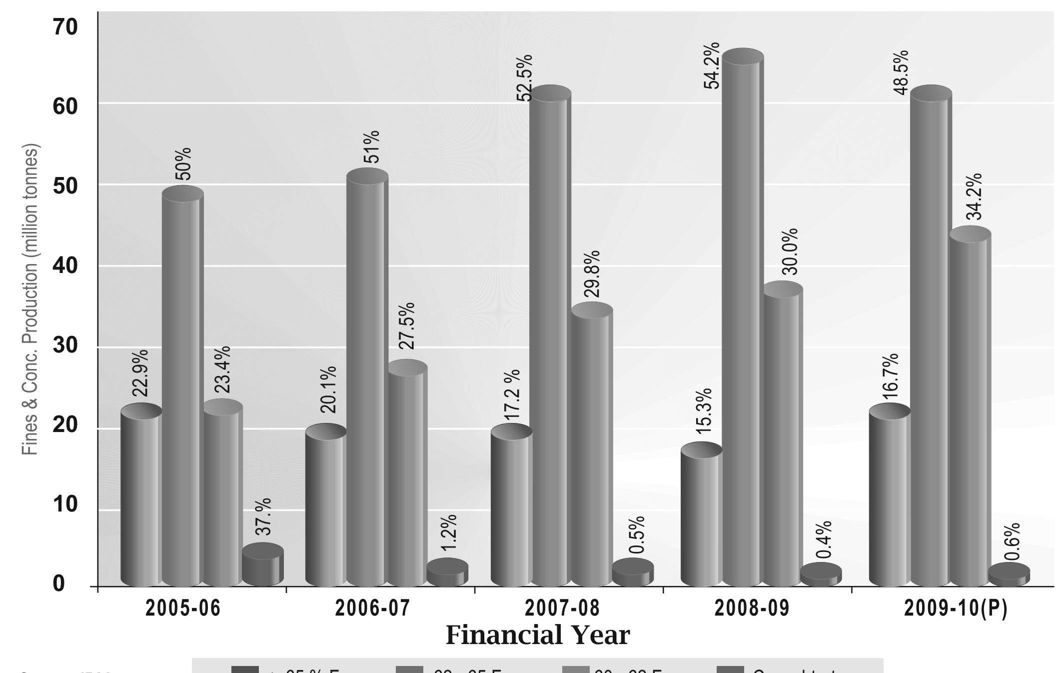
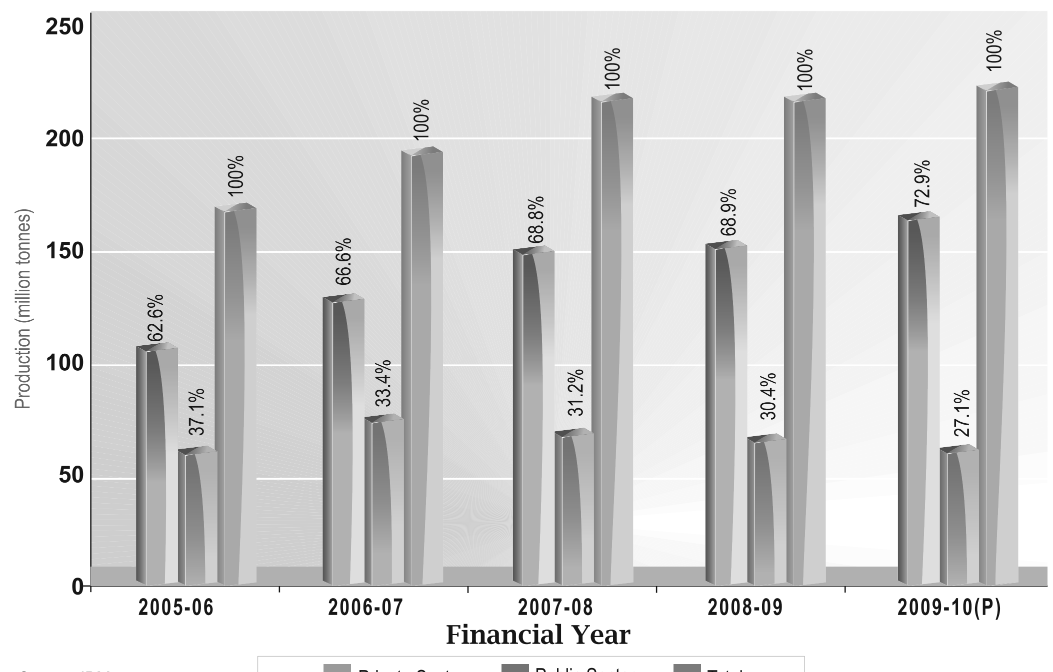


Fig-13: Gradewise Production of Iron Ore Lumps in India



Source: IBM

Fig-14: Gradewise Production of Iron Ore Fines & Conc. in India



Source: IBM

Fig-15: Sectorwise Production of Iron Ore in India

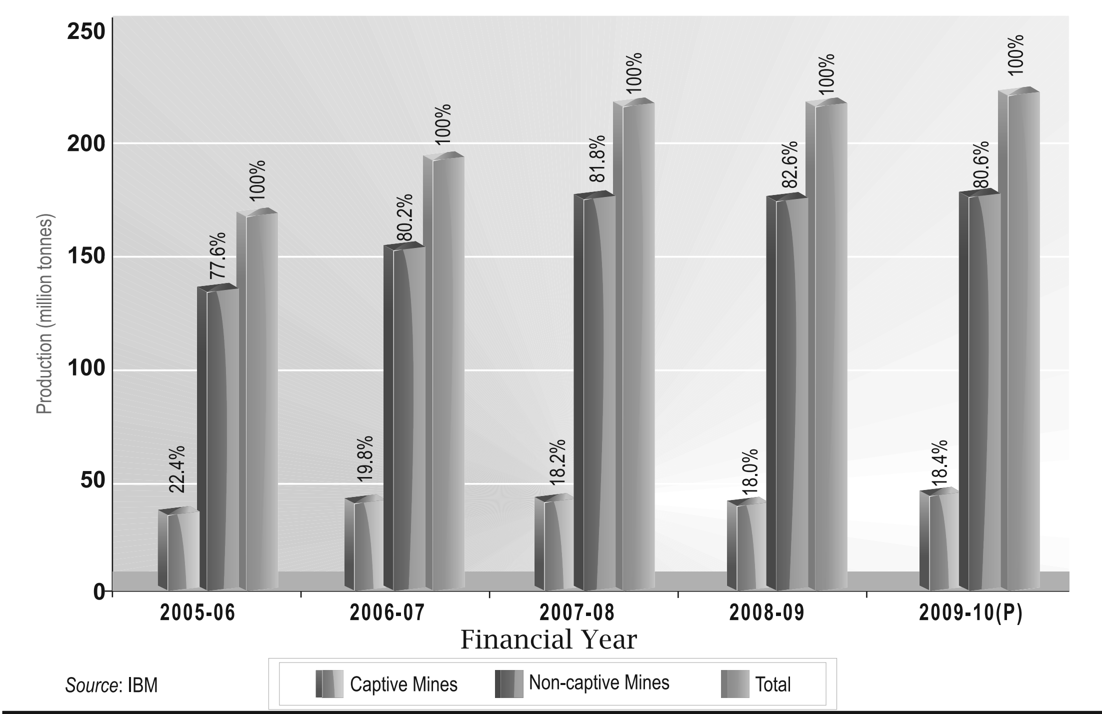


Fig-16: Production of Iron Ore in the Captive/Non-captive Mines of India

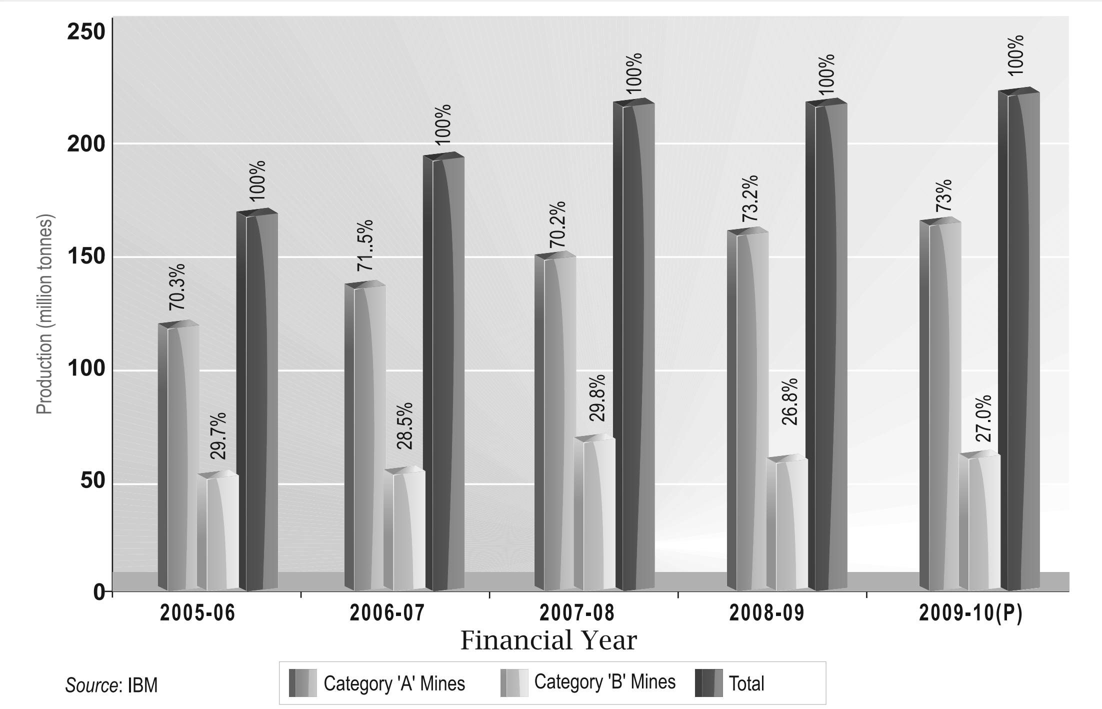
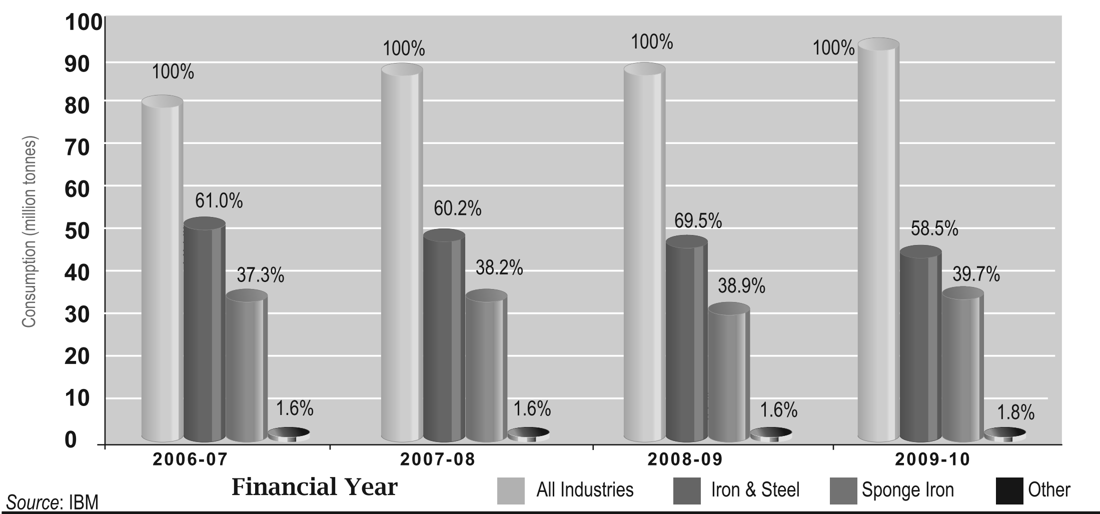


Fig-17: Categorywise Production of Iron Ore in India

2.6.2 Consumption & Export

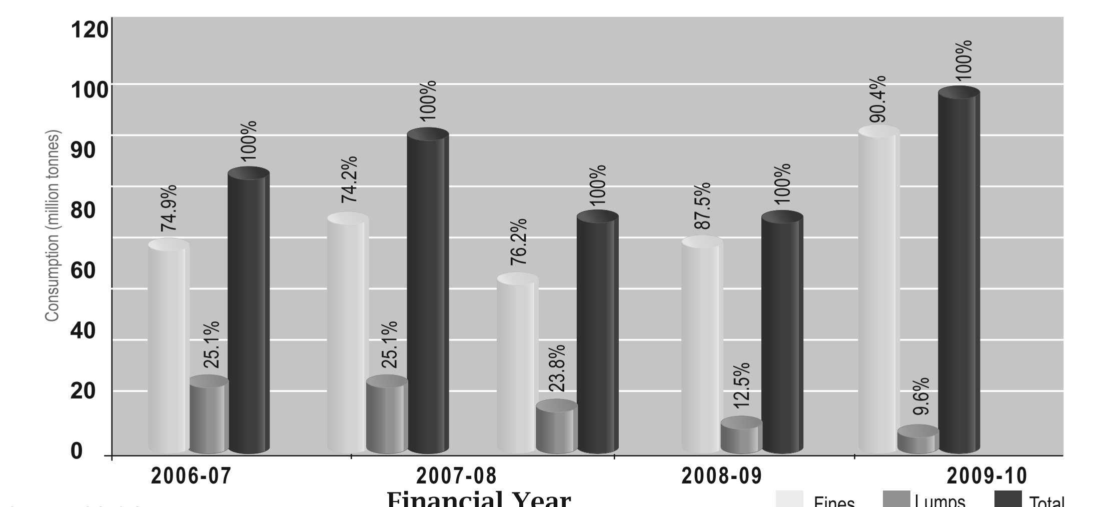
The total domestic consumption of iron ore during 2009-10 was reported to be around 90 million tonnes, of this around 98% was accounted for by iron & steel including sponge iron industries. The remaining 2% was consumed by cement, coal washers, ferro-alloys and other industries such as refractory, chemicals, glass etc. (Fig-18).



Source: IBM

Fig-18: Reported Consumption of Iron Ore by Industries in India

India is the major exporter of iron ore in Asia. Although there are prospects for increasing exports of Indian iron ore in the World, there is a need to review our export policy keeping in view the recent surge in consumption of iron ore by the domestic steel sector. Sizewise export of iron ore during the period from 2005-06 to 2009-10 is presented in Fig-19.



Source: DGCI & S, Kolkata

Fig-19: Sizewise Export of Iron Ore during the Period from 2005-06 to 2009-10

2.6.3 Requirement & Projections

A close look at the production of iron ore (lumps & fines), consumption in steel industry in the form of lumps & sinters and export during the year 2005-06 to 2009-10 indicate that only 40–45% of the overall iron ore production is utilised in steel making and a substantial amount (mostly fines) is exported. Most of the iron ore fines get exported as they cannot be directly used for iron making without agglomeration. Hence, agglomeration i.e., pelletisation in particular, is the only means to further the utilisation of fines in iron making in the near future. This process requires the much-needed attention as it would offset the demand for high-grade iron ore in the country.

The National Steel Policy projected steel production of about 180 million tonnes by 2019-20. About 1.7 to 2 tonnes of processed iron ore (hematite) or 2.5 tonnes of ROM is required to produce 1 tonne of steel. Therefore, to meet the above production level of steel, around 500 million tonnes of r.o.m. iron ore will be required by 2020 inclusive of export.

For the projected steel production (180 million tonnes), existing reserves of hematite are the only source of iron ore and as such, the reserves will not last beyond 15–20 years maximum. Hence, additional domestic resources have to be created on priority.

2.6.4 Specification of Iron Ore

General user specifications of iron ore lumps, fines & concentrates used in making pellets/sinters for iron making is presented in Table-6.

Lumps, Fines & Blue dust	Chemical constituents			
	Fe (T)	SiO_2	Al_2O_3	P
High-grade	65% & above	2% max.	2% max.	-
Medium-grade	62 to 65%	3% max.	3% max.	0.1% max.
Low-grade	60 to 62%	4.5% max.	4% max.	0.1% max.
Unclassified	The range of minimum & maximum value of chemical constituents is too wide to be fitted in to any of the above grade.			

Table-6: End-use Grade specification for Hematite