

23 Chromite

Chromite is an oxide of chromium and iron. The chemical composition of chromite is $\text{FeO} \cdot \text{Cr}_2\text{O}_3$ or FeCr_2O_4 . Chromite contains 68% Cr_2O_3 and 32% FeO with Cr:Fe ratio of about 1.8:1. Chromite is the only commercial source of chromium. It occurs as a primary mineral of ultrabasic igneous rocks and is normally associated with peridotite, pyroxenite, dunitite and serpentinite. Worldwide, high-alumina chromite, largely from podiform deposits is used in refractory applications while iron-rich ores, largely from stratiform deposits are utilised in metallurgical and chemical applications.

RESOURCES

As per UNFC system, total resources of chromite in the country as on 1.4.2010 are estimated at 203 million tonnes, comprising 54 million tonnes reserves (27%) and 149 million tonnes remaining resources (73%). More than 93% resources of chromite are located in Odisha, mostly in the Sukinda valley in Cuttack and Jajpur districts. Minor deposits are scattered over Manipur, Nagaland, Karnataka, Jharkhand, Maharashtra, Tamil Nadu and Andhra Pradesh. Gradewise, charge-chrome grade accounts for 36% resources followed by ferro-chrome grade (19%), beneficiable grade (17%) and refractory grade 5%. Low, others, unclassified and not known grades together account for 23% (Table-1).

EXPLORATION & DEVELOPMENT

GSI carried out reconnaissance stage investigation for chromite around Maulabhanj and Tanageria areas in Dhenkanal district, Odisha, along the transition zone of Eastern Ghat Mobile Belt and Iron Ore Super Group towards south of Sukinda ultramafic complex. Large scale mapping supported by pitting/trenching could establish presence of a linear chromiferous zone over 0.35 sq. km. The visual estimate indicates 20-25% Cr_2O_3 . Earlier, samples collected from old pits analysed Cr_2O_3 from 29.17 to 49.43% & Fe_2O_3 from 17.72% to 34.33%. In Jharkhand, prospecting stage investigation for gold, nickel, PGE and chromite were conducted in Tilaitnar-Sobhapur area in East & West Singhbhum district. Trench samples were being analysed for continuing exploration in the delineated, promising areas. In Manipur reconnaissance study was carried out in ophiolite belt where 3 discontinuous lenses of massive

chromite were observed within serpentinised ultramafics. Exploration was also carried out by Facor Ltd, the details of which are furnished in Table - 2.

PRODUCTION, STOCKS & PRICES

The production of chromite at 3,413 thousand tonnes during 2009-10 decreased by 16% as compared to the previous year owing to uncertainty in market condition and dip in demand.

The number of reporting mines was 23 in 2009-10 as compared to 24 in the preceding year. Six principal producers operating 12 mines together accounted for 91% of the total production during the year. The contribution of 13 mines, each producing more than 20,000 tonnes per annum, was 99.67% of the total production.

The share of public sector in total production was 18% in 2009-10 as compared to that of 29% in the previous year. About 34% of the total production was reported from captive mines in the current year as compared to 38% in the previous year.

Odisha continued to be the major producing state of chromite, accounting for 99.81% production during 2009-10. The remaining was reported from Karnataka and Maharashtra.

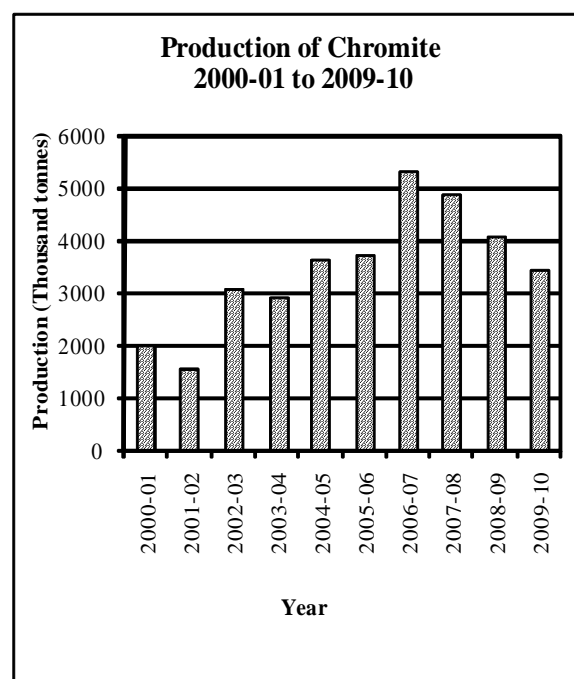


Table – 1 : Reserves/Resources of Chromite as on 1.4.2010 (P)
(By Grades/States)

(In '000 tonnes)

Grade/State	Reserves			Remaining resources					Total resources (A+B)				
	Proved STD111	Probable		Feasibility STD211	Pre-feasibility		Indicated STD332	Inferred STD333		Reconnaissance STD334			
		STD121	STD122		STD221	STD222							
All India : Total	31652	7165	15153	53970	1371	1407	4431	31787	36525	52497	21359	149377	203347
By Grades													
Refractory	4074	923	704	5701	547	-	-	15	240	3262	-	4064	9765
Charge-chrome	10984	868	9565	21417	495	1107	1679	6332	29840	11508	-	50961	72378
Low	26	27	-	53	-	-	-	-	-	3713	-	3713	3766
Beneficiable	8245	2912	2668	13825	255	279	710	12457	1843	5610	-	21154	34979
Ferro-chrome	6304	1689	1353	9346	74	20	88	12805	2794	13280	-	29061	38407
Others	175	746	-	921-	-	-	-	168	15	-	-	183	1104
Unclassified	1844	-	863	2707	-	-	1953	9	1778	14963	21359	40062	42769
Not-known	-	-	-	-	-	1	1	-	16	161	-	179	179
By States													
Andhra Pradesh	-	-	-	-	-	-	-	-	15	172	-	187	187
Jharkhand	-	-	-	-	-	-	-	15	98	623	-	736	736
Karnataka	333	395	17	745	250	218	96	-	20	303	-	887	1632
Maharashtra	53	23	-	76	5	-	-	43	67	441	-	556	632
Manipur	3	21	52	76	-	-	-	-	529	6052	-	6581	6657
Nagaland	-	-	-	-	-	-	-	-	-	3200	-	3200	3200
Odisha	31263	6725	15085	53073	1116	1189	4335	31722	35796	41431	21359	136948	190021
Tamil Nadu	-	-	-	-	-	-	-	7	-	276	-	283	283

Figures rounded off.

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Grade wise analysis of production during 2009-10 reveals that 52 % & above Cr₂O₃ lumps and fines accounted for 14% (Lumps marginal and Fines 14%), 40%-52% Cr₂O₃ for 28% (Lumps 3% and Fines 25%), below 40% Cr₂O₃ for 42% (Lumps 5% and Fines 37%) and chromite concentrates 16% of the total production (Tables 3 to 7).

Mine-head stocks of chromite at the end of 2009-10 decreased by 13% to 1,945 thousand

tonnes as compared to 2,238 thousand tonnes at the beginning of the year. The entire stocks were held in Odisha (Tables 8A & 8B).

The average daily employment of labour in chromite mines during 2009-10 was 5,369 against 6,359 in the previous year. Domestic prices of chromite are furnished in the General Review on Prices.

Table – 2 : Details of Exploration Activities for Chromite, 2009-10

Agency/ State/ District	Location/ Area/ Block	Mapping		Drilling		Sampling (No.)	Remarks Reserves/resources estimated
		Scale	Area (sq km)	No. of bore- holes	Meterage		
FACOR LTD., Odisha Keonjhar	Boula Chromite mine	–	–	19	417.8	–	Additional resources were not estimated, but as on 1.4.2010 about 6.41 lakh tonnes resources of chromite were estimated.
Dhenkanal	Kathpal Chromite Mine	1:2,000 1:500 1:200	– –	55	2606.4	276	As on 1.4.2010 about 1.814 lakh tonnes of chromite resources were estimated.
Jajpur	Gurujang Chromite Mine	1:2,000	72.84 (Ha.)	31	4441.1	196	As on 1.4.2010 about 45.29 lakh tonnes resources of chromite were estimated.

**Table – 3 : Principal Producers of Chromite
2009-10**

Name & address of producer	Location of mine	
	State	District
The Tata Steel Ltd, Bombay House, Fort, Homi Mody Street, Mumbai – 400 001, Maharashtra.	Odisha	Jajpur
The Orissa Mining Corporation Ltd, 'OMC House' Post Box No. 34, Bhubaneswar – 751 001, Odisha	Odisha	Dhenkanal and Jajpur
Balasure Alloys Ltd, Balopalpur, Balasure – 756 020, Odisha.	Odisha	Jajpur

(Contd.)

Table-3 (Concl'd.)

Name & address of producer	Location of mine	
	State	District
Indian Metal & Ferro Alloys Ltd, Bomikhal, P.O. Rasulgarh, Bhubaneswar – 751 010, Odisha.	Odisha	Jajpur and Keonjhar
Ferro Alloys Corporation Ltd, Shree Ram Bhawan, Tumsar, Dist. Bhandara, Maharashtra.	Odisha	Jajpur and Keonjhar
Misrilal Mines (P) Ltd., Vill. Saruabil, P.O. Jajpur Road 755 019 Dist. Jajpur, Odisha.	Odisha	Jajpur

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Table – 4 : Production of Chromite, 2007-08 to 2009-10(P)
(By States)

(Qty in tonnes; value in Rs. '000)

State	2007-08		2008-09		2009-10 (P)	
	Qty	Value	Qty	Value	Qty	Value
India	4872684	21421691	4073479	22633627	3412867	11834079
Karnataka	9488	71131	4115	36475	6457	28109
Maharashtra	-	-	-	-	75	443
Odisha	4863196	21350560	4069364	22597152	3406335	11805527

Table – 5 : Grade wise Production of Chromite, 2008-09
(By Sectors, States and Districts)

(Quantity in tonnes; value in Rs. '000)

State/ District	No. of Mines	Production by Grades : Cr ₂ O ₃ Content							Total	
		Below 40%		40% - 52%		52% & Above			Quantity	Value
		Lumps	Fines	Lumps	Fines	Lumps	Fines	Concentrates		
India	24	194678	1356936	135455	1263848	3868	553990	564704	4073479	22633627
Public sector	10	5954	246404	1083	491898	232	359337	85756	1190664	10613328
Private sector	14	188724	1110532	134372	771950	3636	194653	478948	2882815	12020299
Karnataka	3	2880	189	214	832	-	-	-	4115	36475
Hassan	3	2880	189	214	832	-	-	-	4115	36475
Odisha	21	191798	1356747	135241	1263016	3868	553990	564704	4069364	22597152
Dhenkanal	2	7092	801	8245	1516	3636	-	-	21290	149867
Jajpur	15	130310	1355646	88466	1224708	-	553990	553440	3906560	21982136
Keonjhar	4	54396	300	38530	36792	232	-	11264	141514	465149

Table – 6 : Gradewise Production of Chromite, 2009-10 (P)
(By Sectors, States and Districts)

(Quantity in tones; value in Rs. '000)

State/ District	No. of Mines	Production by Grades : Cr ₂ O ₃ Content							Total	
		Below 40%		40% - 52%		52% & Above			Quantity	Value
		Lumps	Fines	Lumps	Fines	Lumps	Fines	Concentrates		
India	23	159834	1259917	113770	844057	-	482860	552429	3412867	11834079
Public sector	9	6227	48300	253	201038	-	321416	27393	604627	3591146
Private sector	14	153607	1211617	113517	643019	-	161444	525036	2808240	8242933
Karnataka	3	6227	208	-	10	-	-	12	6457	28109
Hassan	3	6227	208	-	10	-	-	12	6457	28109
Maharashtra	1	75	-	-	-	-	-	-	75	443
Bhandara	1	75	-	-	-	-	-	-	75	443
Odisha	19	153532	1259709	113770	844047	-	482860	552417	3406335	11805527
Dhenkanal	2	391	-	17461	2216	-	-	-	20068	121438
Jajpur	13	110026	1259709	68510	818808	-	482860	552417	3292330	11351564
Keonjhar	4	43115	-	27799	23023	-	-	-	93937	332525

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**Table – 7 : Production of Chromite, 2008-09 and 2009-10((P)
(By Frequency Groups)**

(Quantity in tonnes)

Production Group	No. of Mines		Production		Percentage to total production		Cumulative Percentage	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Total	24	23	4073479	3412867	100.00	100.00	–	–
Up to 1000	06	07	105	638	0.00	0.02	–	0.02
1001 - 5000	03	03	8205	10474	0.20	0.31	0.20	0.33
5001 - 10000	01	–	5380	–	0.13	–	0.33	0.33
10001 - 20000	01	–	16372	–	0.40	–	0.73	0.33
20001 - 40000	02	02	60690	49987	1.49	1.46	2.22	1.79
40001 and above	11	11	3982727	3351768	97.78	98.21	100.00	100.00

**Table – 8 (A) : Mine – head Stocks of Chromite, 2009-10
(At the beginning of the year)
(By States/Grades)**

(Quantity in tonnes)

State	Stocks by Grades: Cr ₂ O ₃ Content							Total Quantity
	Below 40%		40% -52 %		52% and above		Concentrates	
	Lumps	Fines	Lumps	Fines	Lumps	Fines		
India	77871	1500905	47208	316015	1242	179534	115639	2238414
Karnataka	4702	20	114	263	–	–	167	5266
Odisha	73169	1500885	47094	315752	1242	179534	115472	2233148

**Table – 8 (B) : Mine – head Stocks of Chromite, 2009-10(P)
(At the end of the year)
(By States/Grades)**

(Quantity in tonnes)

State	Stocks by Grades: Cr ₂ O ₃ Content							Total Quantity
	Below 40%		40% -52 %		52% and above		Concentrates	
	Lumps	Fines	Lumps	Fines	Lumps	Fines		
India	57139	1627666	47544	143721	269	20607	48254	1945200
Karnataka	8852	44	75	–	–	–	179	9150
Maharashtra	125	–	–	–	–	–	–	125
Odisha	48162	1627622	47469	143721	269	20607	48075	1935925

MINING & TRANSPORT

Chromite is mined mostly by opencast method in the country. In OMC's opencast mines, the bench height is less than 6 m and the bench width is more than 10 m in mechanised quarry. The bench height and width is 1.5 m and 2 m, respectively, in the manual quarry. The mining machinery deployed in OMC mines include I.R. & wagon drills for drilling 100 mm dia holes, excavation by Poclain of 1.00 m³ to 3.70 m³ capacity, dozers of 15' blade, loader excavator of 1.70 m³ and dumpers of 16-18 m³ capacity. In some quarries tippers and pay loaders are used in addition to manual means. The motive power is provided by electric generators of 75-160 KVA and portable diesel generators of 5 KVA capacity. In South Kaliapani (quarry D) mine of OMC, the 14 m wide main haulage road was proposed to align with a circular path. The haulage road for removing overburden from quarry face to dump was also to be partially aligned. The altered position will be permanent.

Underground mines are confined to Byrapur in Karnataka and Boula & Kathpal mines in Odisha. A proposal was under consideration to convert Nausahi chromite mines of Indian Metals and Ferro Alloys Ltd (IMFA) into an underground mine. For this purpose, development of inclines from the existing quarry bottom was started. Tata Steel was also contemplating to convert a part of Sukinda chromite mine into an underground mine for which rock mechanics studies by South African consultant have been carried out. Chromite ore body extending to 300 m depth is mined by underground method since 1967 at Byrapur in Hassan district of Karnataka. Here cut-and-fill method of stoping is practised. In Sukinda valley, chromite has been mined to a maximum depth of about 63 m by open-cast method. The maximum overburden to ore ratio is 15:1. In the two underground mines in Odisha-one at Kathpal of M/s Ferro Alloys Corporation Ltd and other at Bangur of IMFA - sub-level stoping with parallel/ring hole blasting with delayed firing is practised. Construction of cement concrete barrier has been planned to provide a base for the fill material at 30 m interval in the dip direction. In Sukinda area, deposits of chromite lying below 100 m depth may have to be exploited by highly specialised underground mining techniques.

OMC was also developing underground mine near Bangur in Baula-Nuasahi chromite belt close to IMFA mining operations. Though positive results were obtained from drilling, systematic exploration

was yet to be taken up. OMC's chromite mines at Kaliapani, Sukrangi, Kalarangi, Kathpal and Bangur, all in Odisha, make it one of the leading chromite producers of the country. Chrome ore of very high grade (+58% Cr₂O₃) is produced here. The chrome ore beneficiation plant at Kaliapani with a total production capacity of 84,000 tonnes concentrates is designed to upgrade low-grade ore below 33% Cr₂O₃. Keeping in view the increasing demand for chrome concentrates, OMC is in the process of doubling the capacity of this plant.

Transportation of the ore from mines to railway sidings is done through trucks and from railway sidings to various consuming centres by railway wagons. In South Kaliapani mine of OMC, the width of haul road was more than 3 times the width of tipper/dumpers plying in the quarry and in some places one way traffic was provided as and when needed. Important loading stations for chromite in the country are Jajpur-Keonjhar Road in Odisha and Tiptur in Karnataka. Export of chromite is through Paradip port. However, small quantities of lumpy chromite ore are imported to meet the needs of ferro-alloys industry in the country.

Research and Development

The Institute of Minerals & Material Technology (IMMT), Bhubaneswar (CSIR) conducted roasting studies for Tata Steel Ltd, Jamshedpur to establish conditions like temperature and time duration for causing structural changes in chromite grains to make it more reactive for further processing to produce ferro-alloy. In another beneficiation study for development of flow sheet on low grade chromite lumps was conducted for Ashapura Minechem Ltd, Mumbai by different processes namely grinding, size analysis, sink float and magnetic separation. From a feed of 30 % Cr₂O₃, a product analysing 40.74% Cr₂O₃ was obtained by continuous semi-autogenous ball mill grinding followed by sieve bend classification. However, the recovery was only 11%. In a study conducted for Ferro Alloys Corp. Ltd investigations were conducted to enrich chrome to iron ratio from two types of concentrates from their chromite ore beneficiation plant. Preliminary studies indicated that Cr:Fe ratio could be enriched to 3.1 from two concentrates with Cr:Fe ratio of 1.86-2.4 and 2.14-2.6

Environmental Problems

Management of waste dump in Sukinda valley is the major environmental concern. These overburden dumps modify the land topography, affect the drainage system, prevent natural

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succession of plant growth resulting in acute problems of soil erosion and environmental pollution.

Normally, waste dumps are maintained up to a height of 20-30 m with 30 m terrace width and slope angle of 25 to 35°. Toe-wall, garland drain, terracing and plantation along the slope are some of the common measures that are being adopted for waste dump management. Neem, Chakunda, Accacia, Mahul, Sal, Mango, Cashew, Arjuna, Babul, Amla, Bahada, Jamun, etc. are the species used in afforestation over dead dump slopes, dump terrace, along the haul roads and safety zones in the mines.

The major source of environmental pollution in Odisha is the hexavalent chromium generation, especially in case of friable ore. The hexavalent chromium contamination of the local water bodies is a major concern because of its carcinogenic properties. The pumped out water from the mine needs to be doused with ferrous sulphate solution before being discharged. The water is then neutralised with addition of lime. The Mining Research Cell, Indian Bureau of Mines, during 2008-09 carried out a study for the attenuation of Hexavalent chromium in Sukinda chrome belt by bio-remediation technology which is apparently environment-friendly. This study was an S&T Project in association with Utkal University.

Environmental problems related to chromium processing are limited. Chromium, in its trivalent (Cr³⁺) oxidation state as found in chromite and other natural minerals, is an essential nutrient. Its principal function is to maintain normal glucose metabolism. Chromium deficiencies can lead to problems in insulin circulation as well as possible risk of cardiovascular disease. Hexavalent form of chromium (Cr⁶⁺) which is used widely in chemical compounds has been implicated in skin rashes and lung cancer.

CONSUMPTION

The reported consumption of chromite in the organised sector increased by 8.4% from 2,161,700 tonnes in 2008-09 to 2,343,600 tonnes in 2009-10. Almost entire consumption (98.7%) was in ferro-alloys/charge-chrome industry. In addition to above, chromite in substantial quantities is also consumed in small-scale ferro-chrome units for which information is lacking. Data on consumption of chromite, ferro-chrome & ferro-chrome-silicon from 2007-08 to 2009-10 are given in Tables 9 to 11.

**Table – 9 : Reported Consumption of Chromite
2007-08 to 2009-10
(By Industries)**

(In tonnes)			
Industry	2007-08(R)	2008-09(R)	2009-10(P)
All Industries	2499200	2161700	2343600
Chemical	4800(2)	4800(2)	4800(2)
Ferro-alloys (including charge-chrome)	2470000 ^(e)	2132000 ^(e)	2314000 ^(e)
Refractory (including iron & steel)	23400(23)	23800(24)	23900(25)
Others (foundry, ceramic, glass)	1000(7)	1100(7)	900(7)

Figures rounded off. Data collected on non-statutory basis. Figures in parentheses denote the number of units in the organised sector reporting consumption. (*Includes actual reported consumption and/or estimates made wherever required). Small scale sector is also producing ferro-chrome for which data is not available.*

**Table – 10 : Reported Consumption of
Ferro-chrome-silicon, 2007-08 to 2009-10
(By Industries)**

(In tonnes)			
Industry	2007-08	2008-09(R)	2009-10(P)
All Industries	460	460	460
Alloy Steel	460(1)	460(1)	460(1)

Figures rounded off. Data collected on non-statutory basis. Figures in parentheses denote the number of units in the organised sector reporting consumption. (*Includes actual reported consumption and/or estimates made wherever required).*

**Table – 11 : Reported Consumption of Ferro-chrome
2007-08 to 2009-10
(By Industries)**

(In tonnes)			
Industry	2007-08	2008-09(R)	2009-10(P)
All Industries	149200	229000	273600
Alloy steel	33200(15)	33400(15)	37700(15)
Electrode	++(3)	++(3)	++(3)
Foundry	700(21)	600(21)	600(21)
Iron & steel	115300 (10)	195000(11)	235300(12)

Figures rounded off. Data collected on non-statutory basis. Figures in parentheses denote the number of units in the organised sector reporting consumption. (*Includes actual reported consumption and/or estimates made wherever required).*

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USES

In metallurgy, chromite is used in the manufacture of chromium metal and various alloys with iron, nickel, cobalt, tungsten, molybdenum, etc. Chromium imparts additional strength, hardness and toughness to its alloys. It also shows resistance to corrosion to steel abrasion, reduces oxidation and flow of electricity. Stainless steel, high-speed tool steel, corrosion and heat-resistant steel are some of the important varieties of chromium steel. Ferro-chrome is of two types: (i) high carbon (containing 4-8% carbon) and (ii) low carbon (containing up to 2% carbon). The amount of chromium used in steel varies with the purpose. Low chromium steels (less than 5% chromium and small amount of nickel) are used in rails, automobiles, armour plates, armour piercing projectiles, etc. Intermediate chromium steels (3-12% Cr and small amounts of W, Mo or Si) are used in high-speed tools, valves for engines and other equipment requiring resistance to abrasion, corrosion and oxidation. Chromium steels include stainless steels (12-18% Cr) and super-stainless steels (12-30% Cr and 7-10% Ni) which are used for cutlery and cooking utensils and in aircraft and high-speed trains, respectively. Chromium (17%) with iron (83%) is also used as ferritic stainless steel to manufacture coins.

Chromite is used in refractory industry because of its resistance to corrosion, high temperature and ability to withstand sudden temperature changes and its chemically neutral character. The ore is used in the form of lumps, bricks or cement in linings, specially of steel furnaces.

Chromite is used for manufacturing important chromium compounds like chromates and bichromates of sodium and potassium, chromium pigments like chromic oxide green and chromic acid which, in turn, are used in chromium-plating solution.

Chromium is an essential trace element for human health. However, some of its compounds are highly toxic and carcinogenic. Environment concerns have reportedly reduced the use of chromite refractories and chromium chemicals.

SUBSTITUTES

Development of substitutes of chromium tends to be deterred by cost performance or the customer appeal of the chromium. There are no substitutes in the stainless steel or super-alloys. Boron, manganese, nickel and molybdenum can be substituted in alloy steels and cast irons. Base metal alloys can sometimes be used in place of stainless steel. Dolomite is an alternative for some refractory bricks. Cadmium yellow is one of the several alternative pigments. However, it is not environmentally acceptable and nickel and zinc are possible substitutes for the protection of decorative coatings.

SPECIFICATIONS

The specifications of chromite vary for different end-use industries. The Cr:Fe ratio is one of the important factors to be considered before deciding the end-use of the mineral. The IS specifications for metallurgical, refractory, chemical and foundry industries are given in Tables 12 to 15.

**Table – 12 : IS Specifications of Chromite for Metallurgical Industry (IS : 10818-1984)
(Reaffirmed in 2003)**

Sl. No	Characteristic (on dry basis)	Grade (%)			
		Low carbon ferro-chrome	High carbon ferro-chrome	Silico-chrome	Charge-chrome
1.	Cr ₂ O ₃ percent, min	48	48	48	44
2.	Total iron percent, max. (as FeO)	15	16	15	18
3.	Al ₂ O ₃ percent	13	13	13	10
4.	SiO ₂ percent, max	5	8	10	12
5.	CaO percent, max	5	5	5	5
6.	MgO percent, max	14	16	14	12
7.	Sulphur* (as SO ₃) percent, max	0.1	0.1	0.1	0.14
8.	Phosphorus* (as P ₂ O ₅) percent, max	0.005	0.02	0.02	0.2
9.	Cr:Fe, min	3:1	2.8:1	3:1	1.6:1
10.	MgO : Al ₂ O ₃	–	1:4	–	–

*Sulphur (as SO₃) and phosphorus (as P₂O₅) may be determined as agreed upon by the supplier and the purchaser.

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Table – 13 : IS Specifications of Chromite for Refractory Industry (IS : 10819-1999) (First Revision)

a) Chemical

Sl. No.	Characteristic (on dry basis)	Grade - I (percent by mass)	Grade - II (percent by mass)	Grade - III (percent by mass)
1.	Loss on ignition	1.5 max	1.5 max	1.5 max
2.	Cr ₂ O ₃	52 min	50 min	48 min
3.	Total iron (as FeO)	16 max	18 max	18 max
4.	SiO ₂	3 max	7 max	9 max
5.	MgO	15 max	15 max	15 max

b) Physical

All the refractory grades of chromite are hard, massive, fine-grained, serpentine-free lumpy ores and in the size range -50 mm to (+) 50 mm.

b) Physical

The material shall be of two grades, namely, fine and coarse. The shape of grains should be mostly sub-angular and the fusion point should not be below 1800°C. The fineness of the two grades of chromite sand shall conform to the following requirement:

I.S. Sieve	Fraction Retained on	
	Fine Grade (F) (%)	Coarse Grade (C) (%)
710 micron	–	5 max
500 micron	–	10 max
355 micron	–	10-25
250 micron	3 max	10-25
212 micron	18 max	10-20
150 micron	70 min	10-20
106 micron		7-20
75 micron		12 max
Pan	12 max	6 max

Table - 14: IS Specifications of Chromite for Chemical Industry (IS : 4737-1982; First Revision, Reaffirmed in 2003)

Sl. No.	Characteristic (on dry basis)	Requirement %
1.	Chromic oxide (as Cr ₂ O ₃), percent by mass, min	44.0
2.	Total iron (as FeO), percent by mass, max	20.0
3.	Alumina (as Al ₂ O ₃), percent by mass, max	14.0
4.	Silica (as SiO ₂), percent by mass, max	7.0
5.	Lime (as CaO), percent by mass, max	3.0
6.	Magnesia (MgO), percent by mass, max	14.0

Table – 15 : IS Specifications of Chromite Sand for Foundries (IS : 6788-1973; Reaffirmed 2003)

a) Chemical

Sl. No.	Constituent (on dry basis)	Requirement (%)
1.	Cr ₂ O ₃	44 min
2.	Fe ₂ O ₃	26 max
3.	SiO ₂	4 max
4.	CaO	0.5 max
5.	MgO	As agreed
6.	Clay	0.75 max
7.	LOI	1.0 max
8.	Moisture	0.5 max
9.	pH value	Between 7.0 and 9.0

INDUSTRY

Chromite is used chiefly in metallurgical industry for manufacture of ferro-alloys; e.g., ferro-chrome, charge-chrome and silico-chrome which are used as additives in making stainless steel and special alloy steel. Ferro-alloys are the essential ingredients for the production of high quality special alloy steel as well as mild steel. The demand for ferro-alloys is associated with the production of alloy steel.

The total combined capacity of chrome alloys (ferro-chrome and charge-chrome) in the country was around 1.30 million tonnes. Production of ferro-chrome/charge-chrome was mainly reported by Ferro Alloys Corp. Ltd, Industrial Development Corporation Odisha Ltd, Tata Steel Ltd, VBC Ferro-alloys Ltd, Indian Charge-chrome Ltd. and Indian Metals & Ferro-Alloys Ltd. As per the Indian Ferro Alloys Producers' Association, 817,239 tonnes and 892,100 tonnes of ferro-chrome/charge-chrome was produced in 2008-09 and 2009-10, respectively. The production of low carbon ferro-chrome was 3,007 tonnes in 2009-10 as compared to 2,371 tonnes in 2008-09. Tata Steel Ltd, Ferro Alloys Corporation Ltd, and Indian Charge-chrome Ltd were amongst the major producers of charge-chrome having a total capacity of 1,62,500 tpy. The charge-chrome contains 50 to 60% chromium and 6 to 8% carbon. Hard lumpy chromite is used for high-carbon ferro-chrome while friable ores and fine briquettes are used for low-carbon ferro-chrome. Briquette fines along with lumpy ores were also consumed in charge-chrome plants.

The important plants which produce chromite-based refractories were Tata Steel Ltd (formerly OMC Alloys), Tata Refractories Ltd, Orissa.

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Industries Ltd, Burn Standard Co. Ltd, Bhilai Refractories Ltd, Joglekar Refractories and Ceramics (P) Ltd, and Associated Ceramics Ltd. The demand for chromite in refractory industry is gradually decreasing.

Indian Ferro-alloys Producers' Association (IFAPA) is understood to have plans to set up a one million tpy ferro-alloys complex at Haldia, West Bengal. The plans include production of ferro-chromium too. FACOR also planned to double its ferro-chrome capacity at Balasore, Odisha to 120,000 tpy; Visa Steel Ltd planned to double its capacity to 100,000 tpy ferro-chrome at Kalinganagar, Odisha and another 100,000 tpy plant in collaboration with Baosteel of China, IMFA's expansion at Choudwar would increase its capacity to 275,000 tpy of ferro-chrome.

There were also reports of stainless steel capacities being added or under planning, notably - Facor at its charge chrome plant in Odisha (500,000 tpy) and at alloy and special steel plant at Nagpur, Maharashtra

(50,000 tpy); Rohit Ferro Tech (200,000 tpy) SAIL, Salem Steel Plant (300,000 tpy) and at ASP, Durgapur (200,000 tpy); Visa Steel (500,000 tpy); Viraj Group (800,000 tpy), Adhunik Metalinks Ltd and Godavari Ispat Ltd (200,000 tpy). Jindal Stainless had plans to increase stainless steel capacity to 2.5 million tpy by 2012. It continued construction of the greenfield plant in Jajpur, Odisha (1 million tpy).

Vishnu Chemicals Ltd has plants at Hyderabad (Andhra Pradesh), Bhilai (Chhattisgarh) and Visakhapatnam (Andhra Pradesh) to produce chromium chemicals. Sodium dichromate capacity at its plants is reported to be 70,000 tpy. There were two units producing chromium chemicals in small quantities in the organised sector; namely, Tamil Nadu Chromates and Chemicals Ltd and Krebs & Cie (India) Pvt. Ltd.

Plantwise specifications of chromite in respect of major user industries are given in Table - 16. For information on ferro-alloys industry, the review on Ferro-alloys may also be referred.

Table – 16 : User's Specifications of Chromite in Major Consuming Industries

Industry/Name and location of plant	Specifications of ore consumed
FERRO - CHROME/CHARGE-CHROME	
Andhra Pradesh	
Andhra Ferro Alloys Ltd, Kothavalasa, Dist. Vizianagram.	NA
Ferro-Alloys Corp. Ltd, Shreeram Nagar, Dist. Vizianagram.	Lumps : Cr ₂ O ₃ 42% size: +25-75 mm SiO ₂ : 10% Cr: Fe ₃ : 3 Fines : Cr ₂ O ₃ 46% -6 mm SiO ₂ : 7% Cr : Fe : 2.6 Friable : 42% Cr ₂ O ₃
Jindal Stainless Steel Ltd, Jindal Nagar, Dist. Vizianagram.	Lumps : Cr ₂ O ₃ 38% Cr:Fe : 2.9
Nav Bharat Ferro Alloys Ltd, Paloncha, Dist. Khammam.	Lumps : Cr ₂ O ₃ 28-42% Fines : Cr ₂ O ₃ 48-50%, 52-54%
GMR Vasvi Industries Ltd, Ravivalasa, Dist. Srikakulam.	Lumps Cr ₂ O ₃ - 38-45% Fines Cr ₂ O ₃ - 45-55 %
VBC Ferro Alloys Ltd, Rudragram, Dist. Medak.	Lumps : Cr ₂ O ₃ 36-52%
Chhattisgarh	
Jindal Steel & Power Ltd, Raigarh.	Lumps : Cr ₂ O ₃ +38% Cr:Fe : 2.9 Fines : Cr ₂ O ₃ +52%, Cr:Fe : 2.6
Deepak Ferro Alloys Ltd, Urla, Dist. Raipur.	Lumps : Cr ₂ O ₃ 36-40% Fines : Cr ₂ O ₃ 48-52%

(Contd.)

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Table - 16 (Concl'd.)

Industry/Name and location of plant	Specifications of ore consumed
Odisha	
Balasure Alloys Ltd, Balgopalpur, Dist. Balasure.	Lumps : Cr ₂ O ₃ 38-45% Fines : Cr ₂ O ₃ 45-48% (medium grade), 48-52% (high grade), 52-55% (super high grade)
FACOR, Charge Chrome Division, Randia, Dist. Balasure.	Lumps : Cr ₂ O ₃ 42% Fines : Cr ₂ O ₃ 46% Friable : Cr ₂ O ₃ 46%
IDCO Ferro Chrome & Alloys Ltd, Jajpur Road.	Cr ₂ O ₃ : 42-52% Cr:Fe : 3.0, SiO ₂ 6% max
Indian Charge Chrome Ltd, Choudwar, Dist. Cuttack.	Cr ₂ O ₃ : 40-48% SiO ₂ : 15% max
Indian Metals & Ferro Alloys Ltd, i) Therubali, Dist. Raygada, ii) Choudwar, Dist. Cuttack.	Lumps & Fines
Tata Steel Ltd, (Formerly OMC Alloys Ltd.) Bamniral, Dist. Keonjhar.	Cr ₂ O ₃ : 47% min Size : 0-40 mm
West Bengal	
Rohit Ferro Tech Ltd, Bishnupur, Dist. Bankura.	NA
Shri Vasavi Industries Ltd, Dist. Bankura.	NA
REFRACTORY	
Chhattisgarh	
SAIL Refractories Unit, Maruda Dist. Durg.	Friable lumps : Cr ₂ O ₃ : 52-54% min, SiO ₂ : 5% max
Vishva Vishal Engineering Ltd, Bhilai, Durg.	Cr ₂ O ₃ : 50% SiO ₂ : 4.5% max Fe ₂ O ₃ : 8%
Jharkhand	
Associated Ceramics Ltd, Chirkunda, Dist. Dhanbad.	NA
Maithan Ceramics Ltd, Dhanbad.	NA
Maharashtra	
Joglekar Refractories & Ceramics (P) Ltd, Rabale, Dist. Thane.	Lumps Cr ₂ O ₃ 44% min, CaO < 2%, Fe ₂ O ₃ < 21% Imported sand - 30 to +85 mesh, Cr ₂ O ₃ 45% min, SiO ₂ < 1%, Fe ₂ O ₃ < 27%
Odisha	
Odisha Industries Ltd, Lathikata Works, Sundergarh.	Cr ₂ O ₃ : 52-54% Fe ₂ O ₃ : 15-18% max SiO ₂ : 3-5%
IFGL Refractories Ltd, Kalunga, Dist. Sundergarh.	Cr ₂ O ₃ : 55% min, -16 to +22 mesh
Tata Refractories Ltd, Belpahar.	Cr ₂ O ₃ : 48-50% min SiO ₂ : 5-9% min
Tamil Nadu	
Burn Standard Co. Ltd, Salem.	Cr ₂ O ₃ : 52-54% min SiO ₂ : 3-5% max Fe ₂ O ₃ : 15-18% max
C. Nataraj Ceramics & Chem. Industry Dalmiapuram, Dist. Triruchirapalli	Lumps, Cr ₂ O + 44%. Fe ₂ O ₃ -25%
CHEMICALS	
Odisha	
Krebs & Cei (India) Ltd, Kalma, Dist. Mayurbhanj.	Cr ₂ O ₃ : 48-55%
Vishnu Chemicals Ltd,	NA

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TRADE POLICY

The Ministry of Commerce and Industries, Department of Commerce, had come out with the new Foreign Trade Policy (FTP) for the period 2009-2014 on 27.8.2009. The policy

came into force from 27.8.2009. As per the present Export-Import Policy, the imports of chromium ore lumps, friable ores and concentrates are freely allowed. The export policy on chromite is as follows:

Item	Policy	Nature of restriction
(a) Chrome ore other than (i) beneficiated chrome ore fines/concentrates (maximum feed grade to be less than 42% Cr ₂ O ₃); and (ii) those categories of chrome ores mentioned as permitted through STEs (State Trading Enterprises)	Restricted	Exports permitted under licence other than categories given below
(b) Beneficiated chrome ore fines/concentrates (maximum feed grade to be less than 42% Cr ₂ O ₃)	STE	Export through MMTC
(c) Chrome ore lumps with Cr ₂ O ₃ not exceeding 40%	STE	Export through MMTC
(d) Low silica friable/fine ore with Cr ₂ O ₃ not exceeding 52% and silica exceeding 4%	STE	Export through MMTC
(e) Low silica friable/fine chromite ore with Cr ₂ O ₃ in the range from 52 to 54% and silica exceeding 4%	STE	Export through MMTC

WORLD REVIEW

World resources of shipping-grade chromite are more than sufficient to meet conceivable demand for centuries. About 88% of world's chromium reserves are concentrated in Kazakhstan (51%) and South Africa (37%). US chromium resources are mostly in Stillwater Complex in Montana. Other countries which possess sizeable quantities of resources are Finland, India, Russia, Turkey, Brazil and Albania. The available data on world reserves of chromite are shown in Table - 17.

The world production of chromite decreased from 23.6 million tonnes in 2008 to 18.7 million tonnes in 2009. South Africa was the leading producer, contributing about 37% to the total

world production, followed by India and Kazakhstan (18% each). Other significant producers were Turkey, Brazil, Russia, Finland and Zimbabwe (Table - 18).

A trend has set in where independent ore producers are being nudged out by consumers of chromite resulting in vertical integration of the industry. Consequently the ferro-chromium producing capacities are migrating from stainless steel producing countries to chromite producing countries. Similarly, upgradation of technological and beneficiation processes such as agglomeration of ore, pre-heating and pre-reduction of furnace feed, closed-furnace technology and recovery of chromium from slags are being followed worldwide.

**Table – 17 : World Reserves of Chromium
(By Principal Countries)
(Shipping Grade)**

(In '000 tonnes)

Country	Reserves
World: Total (rounded)	>350000
India*	44000
Kazakhstan	180000
South Africa	130000
USA	620
Other countries	NA

Source: Mineral Commodity Summaries, 2010.

* India's total resources of chromite as per National Mineral Inventory as on 1.4.2010 are 203 million tonnes of which 54 million tonnes are under reserves category.

**Table – 18 : World Production of Chromium
Ores and Concentrates
(By Principal Countries)**

(In '000 tonnes)

Country	2007	2008	2009
World : Total	23900	23600	18700
Brazil	628	700 ^(e)	700 ^(e)
Finland	556	614	247
India*	4873	3980	3372
Kazakhstan	3687	3552	3333
Russia	777	913	416
South Africa	9647	9683	6865
Turkey	1679	1886	1770
Zimbabwe	614	442	194
Other countries	1439	1829	1803

Source: World Mineral Production, 2005-2009.

* Production of chromite in India in 2007-08, 2008-09 and 2009-10 was 4.9 million tonnes, 4.1 million tonnes and 3.4 million tonnes, respectively.

Canada

Noront Resources Ltd, explored and discovered chromite mineralisation in the McFaulds Lake area of Ontario. Exploration included ground and airborne gravity surveys. Drilling was to continue for resource estimations. A tentative analysis indicated ore having 40% Cr₂O₃ having Cr : Fe ratio of 2:1. Cliffs Natural Resources Inc. planned to produce 400,000 to 800,000 tpy of ferro-chromium from the 1-2 million tpy chromite mine acquired from Freewest Resources Canada Inc. in Ontario.

China

China produces chromite ore, ferro-chromium metal and stainless steel, chromium metal, chemicals and is the leading producer of stainless steel in the world. Its raw stainless steel production capacity was 13 million tonnes per annum. The world demand and prices of chromite reacted to the growth of steel sector in China.

Kazakhstan

Kazakhstan is the third leading producer of chromite after South Africa & India. It also produces chromium metal, chemicals and ferro alloys. After acquiring of Voskhod chromite mine, Mechel OAO (Russia) started production to exploit the 19.5 million tonnes reserves to generate 0.95 million tonnes of concentrates per annum. One third of this will be consumed at its Tikhvin ferro chrome plant in Russia and remainder will be sold. A feasibility study to open a ferro-chrome plant near the Voskod mine was in progress. The study was to be completed by 2009. ENRC constructed a second pelletisation plant of 700,000 tpy and was working on a furnace at Aktobe with 440,000 tpy capacity to be completed by 2012.

South Africa

As the leading producer of chromite in the world, South Africa maintained its position at the top. Many new ventures like Stethite and Mecklenburg projects of Chromex Mining plc (UK), Northam of Cronimet Mining GmbH (Germany), Bokfontein mine of Hernic Ferrochrome (Pty) Ltd., Skychrome property of International Ferro Metals Ltd. (Australia), Boshook & Magareng opencast mines of Xstrata (Switzerland) and others are envisaging addition to production in near future to the existing capacity. Tata Steel Ltd (India) started production from its two 75,000 tpy furnaces from the new ferro-chrome plant at Richard Bay. Chromite supplies were sought from Southern African region. ASA Metals (Pty.) Ltd installed two furnaces of 66 MVA capacity and a beneficiation and pelletisation plant of 600,000 tpy capacity. The company increased its ferro-chromium production capacity from 240,000 tpy to 400,000 tpy. Chromex Mining plc completed a processing plant to treat 40,000 tonnes per month of r.o.m. in 2009.

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USA

Though the country has small chromite reserves, USA is a major producer of chromium metal, ferro-alloys, chemicals & stainless steel. Industrial Minerals Corp. Ltd developed a process for its Oregon Resources Project (ORP) to recover chromite from its paleo-beach placer deposits in Coos County. The shortage of water needed for a typical process of handling placer sand prompted ORP to develop an off site process in which wet sand is taken for processing to a plant 30 km away from the mine and after dewatering, tailings are transported back for reclamation. Proven reserves grading 7.5% Cr₂O₃ at 7.88 million tonnes have been established.

FOREIGN TRADE

Exports

Exports of chromite decreased to 0.69 million tonnes in 2009-10 from 1.9 million tonnes in the previous year. Out of total chromite exported in 2009-10, bulk share of about 74% was of chromite concentrate while chromite lumps and other chromite together accounted for 26%. Exports were mainly to China (90%), Korea (5%) and Japan (4%). In 2009-10, about 7 tonnes of chromium & alloys and scrap was exported mainly to Indonesia (Tables 19 to 23). The exports of ferro-chrome are covered in 'Ferro-alloys' review.

Imports

Imports of chromite increased to 96 thousand tonnes in 2009-10 to 94 thousand tonnes in the previous year. Out of total quantity of chromite imported in 2009-10, lumpy chromite accounted for 93% while concentrate and other forms accounted for remaining 7%. Imports were mainly from Oman (30%), UAE (36%), South Africa (23%) and Turkey (10%). Imports of chromium & alloys and scrap in 2009-10 were 640 tonnes compared to 600 tonnes in the previous year. Imports were mainly from Russia (66%), UK (23%) and China (4%) (Tables 24 to 28). The imports of ferro-chrome are covered in 'Ferro-alloys' review.

**Table – 19 : Exports of Chromite : Total
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	1899028	9736103	689081	8012506
China	1471183	8368073	618976	7189030
Korea, Rep. of	–	–	36618	396440
Japan	416450	1177118	25000	340374
USA	–	–	7785	72522
Netherlands	–	–	574	8770
UAE	3856	60704	36	3300
Belgium	–	–	25	1563
Australia	2000	6768	–	–
Bangladesh	1350	40209	–	–
Chinese Taipei/ Taiwan	4080	81294	–	–
Other countries	109	1937	67	507

**Table – 20 : Exports of Chrome Ore Lumps
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	204313	827899	29784	192175
China	202962	787680	29784	192175
Bangladesh	1350	40209	–	–
Israel	1	10	–	–

**Table – 21 : Exports of Chrome Ore Concentrates
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	1549199	7787724	508831	5737336
China	1130644	6602021	47639	5332125
Korea, Rep. of	–	–	36618	396440
Netherlands	–	–	574	8770
Australia	2000	6768	–	–
Japan	416450	1177118	–	–
Russia	100	1525	–	–
Spain	5	292	–	–
Other countries	–	–	++	1

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**Table – 22 : Exports of Chrome Ore (Others)
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	145516	1120480	150466	2082995
China	137577	978372	117553	1664730
Japan	-	-	25000	340374
USA	-	-	7785	72522
UAE	3856	60704	36	3300
Belgium	-	-	25	1563
Poland	-	-	40	472
Nepal	++	85	27	24
Kenya	-	-	++	6
Chinese Taipei/ Taiwan	4080	81294	-	-
South Africa	3	25	-	-
Other countries	-	-	++	4

**Table – 23 : Exports of Chromium & Alloys
and Scrap
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	11	231901	7	4770
Indonesia	-	-	2	1271
Cameroon	-	-	++	885
Saudi Arabia	-	-	1	525
Egypt	-	-	++	483
Israel	-	-	1	399
UK	4	2031	1	296
USA	++	14441	++	48
China	7	197543	-	-
Netherlands	++	308	-	-
UAE	++	17526	-	-
Other countries	++	52	2	863

**Table – 24 : Imports of Chromite : Total
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	94416	1070152	95842	860966
South Africa	6863	154930	21707	268383
UAE	8230	77205	34523	257698
Oman	71071	630313	28417	221648
Turkey	7007	190547	9356	95448
Iran	483	5025	1520	9941
China	46	2095	137	4467
Mauritius	108	3227	27	479
Philippines	498	4151	-	-
Saudi Arabia	40	1064	-	-
Unspecified	-	-	84	1380
Other countries	70	1595	71	1522

**Table – 25 : Imports of Chrome Ore Lumps
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	52119	513008	89050	760112
UAE	3120	34170	34523	257698
Oman	43186	358740	26109	200996
South Africa	2929	66295	17438	194414
Turkey	1948	44322	9356	95448
Iran	403	4053	1520	9941
China	-	-	80	1306
Philippines	474	3939	-	-
Saudi Arabia	40	1064	-	-
Sudan	19	424	-	-
Unspecified	-	-	24	308
Other countries	++	1	++	1

**Table – 26 : Imports of Chrome Ore
Concentrates
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	1166	15358	14	2408
China	-	-	14	2408
Oman	1166	15358	-	-

**Table – 27 : Imports of Chrome Ore (Others)
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	41131	541786	6778	98446
South Africa	3934	88635	4269	73969
Oman	26719	256215	2308	20652
Germany	-	-	50	916
China	46	2095	43	753
Mauritius	108	3227	27	479
Albania	24	841	-	-
Iran	80	972	-	-
Turkey	5059	146225	-	-
UAE	5110	43035	-	-
Unspecified	-	-	60	1072
Other countries	51	541	21	605

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**Table – 28 : Imports of Chromium & Alloys and Scrap
(By Countries)**

Country	2008-09		2009-10	
	Qty (t)	Value (Rs. '000)	Qty (t)	Value (Rs. '000)
All Countries	600	280271	640	258723
Russia	270	124597	421	144501
UK	84	46310	149	64986
USA	5	9558	10	14658
China	31	13599	28	13487
Japan	11	17615	5	8606
Netherlands	33	16075	11	3883
Germany	13	17446	3	2910
France	51	26828	++	15
South Africa	100	5859	–	–
Unspecified	–	–	6	2470
Other countries	2	2384	7	3207

FUTURE OUTLOOK

An Expert Committee constituted by the Ministry of Steel, Government of India has recommended the need of detailed exploration in all the potential areas in

Odisha, Karnataka and ophiolite belt of North-Eastern region with a view to prognosticate resources to a depth of 500 m in Sukinda belt and estimation of resources in all other potential areas.