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NICKEL

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GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES

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12 Nickel

Nickel, when added in small quantity to iron, increases its properties manifold and makes the product hard and stainless. The reason behind the demand of primary nickel all over the world is for the production of stainless steel. When it is used in plating, it makes the surface tarnish-resistant and provides polished appearance.

Nickel is not produced from primary sources in the country. The entire demand is met through imports. However, it is being recovered as nickel sulphate crystals, a by-product obtained during copper production.

OCCURRENCES & RESOURCES

Important occurrence is nickeliferous limonite in the overburden of chromite in Sukinda Valley, Jajpur district, Odisha, where it occurs as oxide. A suitable process is being developed for its utilisation. Nickel also occurs in sulphide form along with copper mineralisation in East Singhbhum district, Jharkhand.

In addition, it is found associated with uranium deposits at Jaduguda, Jharkhand and process is being developed for its recovery. Other reported occurrences of nickel are from Karnataka, Kerala and Rajasthan. Polymetallic sea nodules are another source of nickel.

As per UNFC, as on 1.4.2010, the total resources of nickel ore have been estimated at 189 million tonnes. About 92% resources; i.e., 175 million tonnes are in Odisha. The remaining 8% resources are distributed in Jharkhand (9 million tonnes) and Nagaland (5 million tonnes). Nominal resources are reported from Karnataka (0.23 million tonnes) (Table - 1).

EXPLORATION & DEVELOPMENT

GSI carried out exploration for PGE during 2012-13 in the state of Chhattisgarh and Maharashtra. Details of exploratory activities is given below In Chhattisgarh, reconnaissance state investigation (G-4) was carried out in Mayurnacha-Kanpara, Jamihor and Madhuban areas in district Jashpur to search for PGE mineralisation in Raigarh-Bilaspur-Surguja belt.

The work components include 100 sq km of Large Scale Mapping (1:12500) supplemented by a quantum of 50 cu. m of pitting & trenching and collection of 30 nos of SSS, 50 nos of BRS and 50 nos. of PTS. In addition to these, 30 nos. of PS 20 nos. of PCS and 40 no of samples for PGE analysis were also accomplished. The area exposes Precambrain rocks comprising mica schist, quartzite, talc-chlorite schist, magnetite-quartz

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

(In million tonnes)

Grade/State	Total reserves (A)	Remaining resources						Total resources (A+B)
		Pre-feasibility		Measured	Indicated	Inferred	Total	
		STD221	STD222	STD331	STD332	STD333	(B)	
All India : Total	**–**	**21**	**21**	**31**	**53**	**63**	**189**	**189**
By Grades								
+ 0.9% Ni	–	13	8	–	18	3	42	42
0.5 to 0.9% Ni	–	8	13	31	21	21	94	94
(+)0.5% Ni, unclassified	–	–	–	–	14	39	53	53
Not-known	–	–	–	–	–	–	–	–
By States								
Jharkhand	–	–	–	–	2	7	9	9
Karnataka	–	–	–	–	–	++	++	++
Nagaland	–	–	–	–	–	5	5	5
Odisha	–	21	21	31	51	51	175	175

Figures rounded off.

schist and actinolite-chlorite schist forming a part of Raigarh-Bilaspur-Surguja metamorphic belt. These rocks are intruded by basic and ultrabasic rocks.

The available PCS data indicates that the MgO content in ultramafics rocks vary between 18.5-37.26%. In AFM diagram, the granites depict Calc-alkaline trend where as the mafic and ultramafic shows Tholeiite trend. In R1-R2 plot by Batchelor and Bowden, (1985) granitoids indicates the syn-collisional signature. The party received analytical results of 105 samples indicates Au content 50 ppb-100 ppb, Ni : 4 ppm to 0.22% Co <2 ppm-385 ppm and Cr-5 ppm-0.32% respectively. The investigation has been completed.

In Maharashtra, reconnaissance stage investigation (G-4) was carried out in Akeri and Khardewadi areas in district Sindhudurg for preliminary assessment for PGE, Ni and chromium with the objective to delineate the zones of PGE, Ni and Cr and to evaluate its potentiality in the mafic-ultramafic rocks of the Sindhudurg belt.

The gneiss-migmatite rocks containing the dismembered lenticular bodies of mafic-ultramafic suite of rocks of Precambrain age represent the investigation area. The length of these bodies ranges from few hundred meters to nearly more than a kilometre. An ultramafic body with strike length of more than a kilometre was brought out during Large Scale Mapping and its is located to the south of major Akeri ultramafic body. Disseminations of chromite were recorded along some randomly oriented weak planes as well as along schistosity planes. Another ultramafic rock essentially composed of serpentine showed the presence of nearly 50 micron sized gold grain (nder EPMA).

Few rock-cut groove samples in the ultramaifc body have yielded Ni values of 0.2% to 1%. One sample has yielded a significant PGE value of 275 ppb amongst many other samples. A coarse grained amphibolite occurring on the northern peripheral zone of Akeri ultramafic body showed the presence of multiple sulphide phases viz., pyrrotite-millerite-pentlandite-chalcopyrite. Micro-probing, ore-microscopy, SEM studies etc. and XRD analysis showed the presence of tremolite, serpentine chabazite chlorite, nimite (nickel mineral), jahnsite in the ultramafic rocks.

The investigation will be continued.

INDUSTRY

Nickel sulphate is produced as a by-product at the Ghatsila Copper Smelter of HCL in Jharkhand. The sulphide copper ore from Ghatsila area contains nickel in small quantity along with other important metals like gold and cobalt. The installed annual capacity of the plant to produce nickel sulphate is 390 tonnes. However, the production of nickel sulphate has not been reported since 2004-05. Ronuk Industries, Mumbai is also reported to produce nickel sulphate. Sterlite (Thoothukudi) had developed innovative method to produce pure commercial grade nickel sulphate from electrolyte by solvent crystallisation. The pilot-scale trials are in progress.

Nickel sulphate is an important compound used commercially in the country in nickel plating, in dip baths for enamelling, in preparation of nickel compounds and as a catalytic nickel.

RESEARCH & DEVELOPMENT

Department of Ocean Development

The Department of Ocean Development, under its Polymetallic Nodules (PMN) Programme, has set up on behalf of HZL; a semicontinuous demonstration pilot plant to process 500 kg per day polymetallic nodules for extraction of metal values at Udaipur. The Department of Ocean Development collected 45 tonnes nodules for this purpose. Regional Research Laboratory (RRL) (now IMMT), Bhubaneswar and HZL, Udaipur, are pursuing the R&D efforts for optimising the metal recovery/processing steps.

Institute of Minerals and Materials Technology (IMMT) (formerly RRL), Bhubaneswar

The Nickel Technology Proving Plant set up at Institute of Minerals and Materials Technology, Bhubaneswar is a joint (R&D) pilot project of Council of Scientific & Industrial Research (CSIR) and HZL. In this project, all the experimental studies on nickel plant have been completed.

IMMT is also engaged in extraction of nickel and cobalt from lateritic nickel/chromite overburden of Odisha through microbial route using acidophilic micro-organism. Up to 35% Ni and 50% Co recovery was achieved through mechano-chemical activation and pelletisation of chromite overburden. In a span of 60 days, 70% Ni and 60% Co recovery was achieved. The technology could be exploited in ultramafic complexes of Sukinda Valley. At present, it is to be scaled up to 10-tonne scale to generate process data and basic engineering details with support from OMC Ltd for its commercial implementation at Sukinda mine site.

During the year 2011, IMMT had undertaken R&D project by way of dry beneficiation studies to enrich the nickel content from the waste lateritic nickel-bearing chromite overburden materials of Sukinda. It has also undertaken amenability study of nickel ore for physical beneficiation for M/s CDE Asia Ltd, Kolkata.

IMMT developed a process for production of nickel concentrate from chromite overburden nickeliferous lateritic ores. A process was also developed for extraction of nickel from solutions containing nickel and sodium sulphate and an improved process for dissolution of nickel-cobalt mixed sulphides. Patents were granted for all the three processes in India.

IMMT had carried out and completed beneficiation studies on low grade nickel ore for M/s Jindal Stainless Ltd, Bhubaneswar, Odisha.

USES

The most important use of nickel is in production of stainless steel and other corrosion-resistant alloys. Nickel/chrome plating is still the most widely used decorative electroplated finish on metals. Conventional plating is still much in favour but other techniques such as electrolytic coating or sintered slurry coating are used for applications like turbine blades, helicopter rotors, rolled steel strips and extrusion dies. Nickel is an important ingredient in coins. Finely divided nickel is used as a catalyst in hydrogenation. Other commercial uses are in ceramics, special chemical vessels, rechargeable nickel-cadmium storage batteries, electronic circuits, in computer hard discs, jewellery, green colouring of glass and preparation of nickel compounds.

CONSUMPTION

World over stainless steel is the major end-use sector of nickel having over 66% consumption share. Other uses include, electroplating (8%), other steel alloys, including casting (24%) and other chemical applications, like nickel-cadmium battery (3%). Domestic consumption of ferro-nickel during 2010-11, 2011-12 and 2012-13 was 2,000 tonnes, 2,235 tonnes and 2,235 tonnes, respectively, all in alloy-steel industry.

SUBSTITUTES

Aluminium, coated steels, plain chromium steels and plastics can replace stainless steel to a limited extent in many construction and transportation applications. Nickel-free speciality steels are sometimes used in place of stainless steel within the power- generating, petrochemical and petroleum industries. Titanium alloys or speciality plastics can substitute nickel metal or nickel-based alloys in highly corrosive chemical environments.

TRADE POLICY

As per Foreign Trade Policy, 2009-2014, imports of nickel ores & concentrates (heading no. 2604) and metal (heading no. 7503) are allowed freely. However, some forms of metal waste & scrap (ITC-HS Code No. 7503 0090) are restricted.

WORLD REVIEW

The world reserves of nickel are estimated at 74 million tonnes of metal content. Australia (24%), New Caledonia (16%), Brazil (11%), Russia (8%), Cuba (7%), Indonesia & South Africa (5% each) and Canada & China (4% each) together accounted for around 84% nickel reserves (Table-2). The identified land-based reserves analysing on an average of 1% nickel or more contain at least 130 million tonnes nickel. About 60% of nickel reserves are in laterites and 40% in sulphide deposits. In addition, extensive deep-sea resources of nickel are in manganese crusts and nodules, covering large areas of the ocean floor, particularly in the Pacific Ocean.

Table – 2 : World Reserves of Nickel (By Principal Countries)

(In '000 tonnes of nickel content)

Country	Reserves
World: Total (rounded)	**74000**
Australia	18000
Brazil	8400
Canada	3300
China	3000
Colombia	1100
Cuba	5500
Dominican Republic	970
Indonesia	3900
Madagascar	1600
New Caledonia	12000
Philippines	1100
Russia	6100
South Africa	3700
USA	160
Other countries	5100

***Source**: Mineral Commodity Summaries, 2014.*

Table – 3 : World Mine Production of Nickel (By Principal Countries)

(In '000 tonnes of metal content)

Country	2010	2011	2012
World: Total	**1540**	**1823**	**1895**
Australia	169	215	244
Brazil	66	74	87
Canada	158	220	204
China	80	90	93
Colombia	49	38	52
Cuba	66	66	68
Dominican Republic	–	13	15
Indonesia	217	226	253
New Caledonia	131	129	132
Philippines	184	319	318
Russia	270	270	269
South Africa	40	43	46
Other countries	110	120	114

***Source:** World Mineral Production, 2008-2012.*

In 2012, world mine production of nickel increased marginally to 1.89 million tonnes as compared to 1.82 million tonnes in the previous year. Philippines, Russia, Indonesia, Australia & Canada, New Caledonia, China and Brazil & Cuba were the principal producers (Table-3). Almost all nickel producing countries showed increase in production, significant among them are Philippines, Canada and Australia.

FOREIGN TRADE

Exports

Exports of nickel and alloys including waste & scrap increased substantially to 21,615 tonnes in 2012-13 from 5,340 tonnes in the previous year. Out of the total alloys and scrap exported in 2012-13, nickel alloys were 21,338 tonnes, while nickel waste & scrap were 277 tonnes. Exports were mainly to Singapore, UAE, Netherlands, USA, Latvia & Japan (Tables-4 to 7).

Imports

During 2012-13, imports of nickel ores & concentrates decreased manifold to only 865 tonnes in comparison to 41,729 tonnes in the previous year. Imports were mainly from Australia & China. Imports of nickel & alloys including scrap were 54,424 tonnes in 2012-13 compared to 34,787 tonnes in the previous year. Out of total alloys and scrap imported in 2012-13, nickel alloys were 53,755 tonnes, while nickel waste & scrap was 669 tonnes as compared to 1,129 tonnes in the previous year. Imports in 2012-13 were mainly from Russia, Australia, Canada and Norway (Tables - 8 to 12).

Table – 4 : Exports of Nickel ores and conc. (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**450**	**128258**	**86**	**1478**
China	-	-	86	1478
Other countries	450	128258	-	-

Table – 5 : Exports of Nickel and Alloys Incl. Scrap (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**5340**	**5886670**	**21615**	**22779895**
Singapore	43	53631	15386	16023740
UAE	3640	4119391	4077	4534156
Netherlands	62	72410	561	556888
USA	270	381662	361	471895
Latvia	147	188447	129	159956
Japan	101	86428	92	76371
Mexico	45	46037	61	75620
Thailand	71	82786	53	65827
Turkey	64	71234	60	61894
France	25	49247	40	57531
Other countries	872	735397	795	696018

Table – 6 : Exports of Nickel & Alloys (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**5218**	**5842047**	**21338**	**22663186**
Signapore	43	53631	15386	16023740
UAE	3640	4119369	4077	4534156
Netherlands	62	72410	553	556029
USA	254	377444	270	436641
Latvia	147	188447	129	159956
Mexico	45	46037	61	75620
Thailand	71	82786	53	65827
Turkey	64	71234	60	61894
France	25	49247	40	57531
Saudi Arabia	34	47763	49	54561
Other countries	833	733679	660	637231

Table – 7 : Exports of Nickel Waste & Scrap (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**122**	**44623**	**277**	**116709**
USA	16	4218	91	35254
UK	46	11771	88	34384
Japan	29	16554	42	22651
Germany	14	1457	24	13842
Belgium	4	1773	22	7514
Italy	-	-	2	1964
Netherlands	-	-	8	859
Iran	-	-	++	112
Korea, Rep. of	2	907	++	100
Kenya	-	-	++	18
Other countries	11	7943	++	11

Table – 8 : Imports of Nickel Ores & Conc. (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**41729**	**2008548**	**865**	**808473**
Australia	234	231344	716	698050
China	66	61364	100	106881
Germany	-	-	49	3542
Other countries	41429	1715840	-	-

Table – 9: Imports of Nickel and Alloys Incl. Scrap (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**34787**	**39121536**	**54424**	**55264147**
Russia	11292	12512664	24768	23499754
Australia	3901	4352679	9659	9889777
Norway	3603	3863241	3155	3428726
Canada	1716	2033424	3259	3271564
Japan	1539	1683518	1989	2063874
UK	1908	2303601	1572	1948143
Finland	1281	1418750	1847	1796707
China	1549	1817296	1107	1220987
USA	1044	1306467	841	1188804
South Africa	1186	1439778	1130	1124600
Other countries	5768	6390118	5097	5381211

Table – 10: Imports of Nickel & Alloys (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**33658**	**38729885**	**53755**	**54973981**
Russia	11292	12512664	24768	23499754
Australia	3901	4352679	9659	9889777
Norway	3603	3863241	3155	3428726
Canada	1716	2033424	3259	3271564
Japan	1539	1683518	1987	2063169
UK	1907	2303171	1569	1946056
Finland	1281	1418750	1847	1796707
China	1538	1806617	1105	1218340
USA	840	1228813	750	1156813
South Africa	1186	1439778	1130	1124600
Other countries	4855	6087230	4526	5578475

Table – 11: Imports of Nickel Waste & Scrap (By Countries)

Country	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	**1129**	**391651**	**669**	**290166**
UAE	296	128362	115	63447
Kuwait	-	-	81	45980
Iran	-	-	90	37125
USA	204	77654	91	31992
France	-	-	75	29190
Malaysia	-	-	60	14043
Germany	21	5227	33	13762
Italy	333	88123	42	12784
Sweden	-	-	14	7472
Saudi Arabia	53	24302	16	6900
Other countries	222	67983	52	27471

Table – 12 : Imports of Nickel
(By Items)

All Items	2011-12		2012-13	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Items	**34787**	**39121536**	**54424**	**55264147**
Nickel & alloys	33658	38729885	53755	54973981
Bars, rods, plates, sheets foils of nickel	505	783656	1017	1371834
Bars, rods, plates, sheets foils of nickel alloys	1750	2892051	1592	2725828
Nickel electroplated anode	12	15959	++	215
Nickel & alloys: worked	747	1062367	4156	5251126
Nickel & alloys: worked NES	453	612543	350	483675
Nickel & alloys: unwrought	2957	3479620	950	894671
Nickel: worked	2	5440	6	17096
Nickel except electroplated anode	27225	29871575	45679	44223586
1Nickel mattes	++	1	1	1506
Nickel oxide sinters & qtr intermediate	7	6673	4	4444
Nickel (scrap)	1129	391651	669	290166

FUTURE OUTLOOK

Over 60% of world nickel demand is for the production of stainless steel. Nickel accounts for 10 to 20% input cost in stainless steel production depending on the nickel content. The future outlook for nickel depends mainly on the production of stainless steel which is one of the main drivers for nickel produced. The production of stainless steel is estimated to be 5 million tonnes by 2016-17 as per the 12th Five Year Plan Report.

India will have no option but to depend on imports for this metal till a technology to recover nickel from the overburden of chromite ore in Odisha is established on a commercial scale.