

COBALT



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COBALT

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## 4 Cobalt

Cobalt is an important ferromagnetic strategic alloying metal having irreplaceable industrial applications. Cobalt is associated mostly with copper, nickel and arsenic ores.

### RESOURCES

Occurrences of cobalt are reported from Singhbhum district, Jharkhand; Kendujhar and Jajpur districts, Odisha; Jhunjhunu district, Rajasthan; Tuensang district, Nagaland; and Jhabua and Hoshangabad districts, Madhya Pradesh. Cobalt associated with lateritic nickel deposit in Sukinda area, Odisha and copper slags are two possible secondary resources of cobalt along with sea-bed multimetal nodules.

As per UNFC system, resources of cobalt in terms of ore as on 1.4.2010 are estimated at 44.91 million tonnes of which about 69%, i.e. 30.91 million tonnes are estimated in Odisha. The remaining 31% resources are in Jharkhand (9 million tonnes) and Nagaland (5 million tonnes). Resources of cobalt as per UNFC system are furnished below in Table-1.

### USES

Major use of cobalt is in metallurgical applications, in special alloy/super alloy industry, in magnets and cutting tools industries. Cobalt-based super alloys normally contain 45% or more cobalt while nickel and iron-based super alloys contain 8 to 20% cobalt. Cobalt oxide is used in chemical applications such as catalyst, dyes and

pigments, paint driers/adhesives and glass & ceramics. Cobalt catalyst, mostly cobalt acetate, is used in terephthalic acid (TPA) and di-methyl-terephthalate (DMT) manufacture.

Super alloys made of cobalt have improved strength and wear & corrosion-resistance characteristics at elevated temperatures. Another use of cobalt-based super alloys is in turbines for pipeline compressors and jet aircraft engines. Hard-facing or cutting tools with cobalt alloys provide greater resistance to wear, heat, impact and corrosion. Cobalt powder finds an important application as a binder in the production of cemented tungsten carbides for heavy-duty and high-speed cutting tools. Cobalt powder is used for bonded tools for diamond industry. Cobalt is also used to promote the adherence of enamel to steel in appliances, and also of steel to rubber for manufacturing steel-belted tyres. Cobalt-molybdenum-alumina compound is used as catalyst in hydrogenation and for petroleum desulphurisation. Elemental Cobalt-60 (radioactive isotope, a production of atomic pile) is used in industrial radiography and therapeutics. Cobalt can retain ferromagnetic property up to a temperature of 1,100°C, highest for any metal. It is used in manufacturing of Alnico magnets, magnetic recording media, soft magnetic material, alloys for spacecraft, etc. The use of cobalt-rare earth permanent magnet will continue where specific advantages of reliability and good performance are required. Other significant uses of cobalt are in battery electrodes, airbags in automobiles, etc.

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

(In million tonnes)

State	Reserves total (A)	Remaining resources				Total (B)	Total Resources (A+B)
		Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334		
<b>All India</b>	–	<b>30.63</b>	<b>2</b>	<b>0.28</b>	<b>12</b>	<b>44.91</b>	<b>44.91</b>
Jharkhand	–	–	2	–	7	9	9
Nagaland	–	–	–	–	5	5	5
Odisha	–	30.63	–	0.28	–	30.91	30.91

## RESEARCH & DEVELOPMENT

National Metallurgical Laboratory, Jamshedpur has developed a process route comprising reductive roast and ammonia leaching for the extraction of these strategically important metals from the sea nodules. Due to various reasons, the Co recovery was never more than 60% though Cu and Ni extractions were more than 90% in this process. Laboratory scale experiments have shown that cobalt recovery can be improved with certain additives during leaching. Some of them were found to be effective in enhancing cobalt recovery, without affecting Cu and Ni recovery.

IMMT (formerly RRL), Bhubaneswar had been engaged in extraction of cobalt along with nickel from lateritic nickel/chromite overburden of Odisha through microbial route using acidophilic micro-organism. Up to 35% Ni and 50% Co recovery was achieved. In a span of 60 days, 70% Ni and 60% Co was recovered. The technology was to be scaled up to 10 tonnes with support from OMC. IMMT was granted a patent in India for an improved process for dissolution of nickel-cobalt mixed sulphides. Further developments have not been reported.

HZL carried out R&D with a view to technology absorption in respect of production of cobalt oxide from waste residue of zinc smelter, Debari in Udaipur district, Rajasthan.

## INDUSTRY & PRODUCTION

Presently, there is no production of cobalt in the country from indigenous ores. The refined production of cobalt was reported to be around 1,001 tonnes in 2009, 1,187 tonnes in 2010 and 1300 tonnes in 2011 from imported feed material. The remaining demand of cobalt is met through imports.

Refining capacity of cobalt in India is estimated at about 2,560 tonnes per year. Of these, Nicomet Industries Ltd and Rubamin Ltd were India's leading producers of cobalt cathodes and compounds. Installed capacity for cobalt at Nicomet is 1,000 tpy. Another cobalt refinery, Conic Metals Ltd, Mumbai which produced cobalt sulphate and carbonate reportedly remained closed since 2001.

The refiners source the heterogeneite-type cobalt ores from the Democratic Republic of Congo and other countries. The units manufacture high-purity cobalt metal and salts, viz, sulphate,

acetate, oxide, chloride, carbonate and nitrate of cobalt. Cobalt metal powder is reportedly recovered from cemented carbide scrap by Sandvik Asia Ltd at its pilot plant in Pune, Maharashtra. In addition, spent cobalt catalysts from plants producing DMT, TPA and oxo alcohols are also understood to be reprocessed by several small cobalt chemical processors. However, information on reprocessing of cobalt from scrap is not available. It is expected that recycled cobalt would continue to be used for domestic supply.

## SUBSTITUTES

Cobalt is used in specialised applications and is difficult to be substituted. Potential substitutes include barium or strontium ferrites, neodymium-iron-boron or nickel-iron alloys in magnets; nickel, cermets or ceramics in cutting and wear-resistant materials; nickel-based alloys or ceramics in jet engines; nickel in petroleum catalysts; rhodium in hydroformylation catalysts; and cerium, lead, manganese, iron, or vanadium in paints. Presently, about one-third of cobalt is replaced by cobalt-manganese-nickel in lithium-ion batteries.

## TRADE POLICY

As per the Foreign Trade Policy 2009-2014, imports of cobalt ores & concentrates under heading no. 2605 and cobalt alloys and its products under heading no. 8105 are allowed freely, except cobalt waste & scrap (ITC-HS Code No. 8105 3000) which are restricted.

## WORLD REVIEW

The world cobalt reserves are estimated at 7.5 million tonnes of metal content. Cobalt reserves are mainly in the Democratic Republic of Congo (DRC) which contributes 45% to the total reserves. Besides, major reserves are located in Australia, Cuba, New Caledonia, Zambia and Russia. Majority of these reserves are in nickel-bearing laterite deposits and rest in nickel-copper sulphide deposits hosted in mafic and ultramafic rocks in Australia, Canada and Russia and in sedimentary copper deposits of Congo (DRC) and Zambia. Several million tonnes of potential resources of cobalt are also contained in sea-bed manganese nodules. Exploitation of cobalt-bearing manganese nodules from the deeper parts of the sea may be witnessed in the present century. The world reserves of cobalt are given in Table-2.

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

(In '000 tonnes of metal content)

Country	Reserves
<b>World: Total (Rounded)</b>	<b>7500</b>
Australia	1200
Brazil	89
Canada	140
China	80
Congo, Dem. Rep. (Kinshasa)	3400
Cuba	500
Morocco	20
New Caledonia	370
Russia	250
USA	33
Zambia	270
Other countries	1100

*Source: Mineral Commodity Summaries, 2013.*

The world mine production of cobalt in terms of metal content increased to 151,000 tonnes in 2011 from 136,000 tonnes in the previous year. The Democratic Republic of Congo (DRC) was the principal producer contributing about 72%, followed by Canada & China (5% each), Zambia (4%), Australia & Cuba (3% each) and Brazil, New Caledonia, Russia (2% each) (Table-3).

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

(In tonnes of metal Content)

Country	2009	2010	2011
<b>World: Total</b>	<b>87000</b>	<b>136000</b>	<b>151000</b>
Australia	5365	4838	4254
Brazil	2075	3139	3150
Canada	3919	4636	7071
China	6000	6500	6800 <sup>e</sup>
Congo, Dem. Rep.	56258	97693	108888
Cuba	3500 <sup>e</sup>	3721	3850
Morocco	1600	1582	1518
New Caledonia	913	1735	2404
Philippines	1500	1500	1500
Russia	2352	2460	2337
Zambia	1535	5134	5956
Other countries	1983	3062	3272

*Source: World Mineral Production, 2007-2011.*

### Australia

The Yakubu Ni-Co refinery in Townsville, Queensland (2631 tonnes refined Co), BHP Billiton, W. Australia (500 tonnes Co sulphide), Glencore's Murrin Murrin Ni-Co-laterite mine, W. Australia (2091 tonnes Co metal), First Quantum Minerals Ltd (200 tonnes of Co), Panoramic Resources Ltd (453 tonnes of Co) and Xstrata Nickel Australasia (396 tonnes of Co) were the noteworthy producers in 2011. OJSC, MMC, Norilsk Nickel also started production from the Lake Johnston nickel sulphide mine and mill during the year 2011.

### Belgium

Umicore's 2011 cobalt refinery production increased to 3187 tonnes due to greater availability of scrap resulting from higher prices and higher levels of downstream production. Umicore converted cobalt metal, residues and other cobalt-bearing materials into a wide range of cobalt speciality products, including metal powders, hydroxides, oxides, salts and compounds. Umicore built plants in S. Korea, Japan & in Hoboken, Belgium using recycling facility for spent rechargeable batteries and battery manufacturing scrap .

### China

China's total production of refined cobalt made it the world's leading producer. Most of the production was from imported ores, concentrates and semi-refined materials sourced from Congo (Kinshasa).

### Congo (Kinshasa)

Congo(Kinshasa) was the world's leading producer of mined cobalt. Some of Congo (Kinshasa's) ores and concentrates were exported, some were processed to semi-refined materials such as cobalt carbonate, cobalt hydroxide or cobalt bearing alloys and some were refined to cobalt metal.

Boss Mining had commissioned the new Copper solvent extraction portion of its new cobalt solvent extraction - electrowinning (SX-EW) plant at Luita, but had suspended the cobalt extraction portion due to its economic viability. In 2011, Mutanda mined Copper-Cobalt oxide ore from open pits near Kolwezi and produced 7,900 tonnes of Cobalt in concentrate and hydroxide.

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### **Finland**

Talvivaara Mining Co. Plc continued to ramp up and optimise production from its polymetallic sulphide mine and bioheap-leaching operation in Sotkamo in central Finland. In 2011, Talvivaara sold nickel-cobalt sulphide containing approx. 400 tonnes of cobalt to Norilsk for processing at Harjavalta.

### **Japan**

Sumitomo planned to increase Niihama's production capacity to accommodate the nickel-cobalt mixed sulphide feed that would be generated from its Taganito project in the Philippines. Sumitomo's production of electrolyte cobalt at its Niihama nickel refinery increased by 4% in 2011.

### **New Caledonia**

Vale completed commissioning of its Vale New Caledonia project in the southern tip of New Caledonia's main island and produced 245 tonnes of cobalt. The project, which was originally called Goro, comprised a nickel-cobalt-laterite mine, high pressure acid leaching processing plant and refinery. Vale expected to ramp up production to reach the nominal production capacity of 60,000 tonnes per year of nickel contained in nickel oxide and 4,600 tonnes per year of cobalt contained in cobalt carbonate.

### **South Africa**

The Nkomati nickel sulphide mine produced 513 tonnes of cobalt in 2011 (667 tonnes in 2010). At full steady-state production forecast for 2014, the mine was expected to produce 1,000 tpy of cobalt in concentrates.

Some of South Africa's PGM operations produced cobalt sulphate at its base metal refinery. Rustenburg Base Metal Refinery, North West Province and Impala Platinum Ltd near Springs, Gauteng Province produced cobalt metal powder at its base-metal refinery. Two other platinum

producers - Lonmin plc and Northam Platinum Ltd operated base-metal refineries and produced semi-refined nickel sulphate containing cobalt.

### **Zambia**

Konkola Copper Mines Plc (KCM) mined copper ores from its Nchanga open pit and Konkola operations. China Non-ferrous Metal Mining Group Co Ltd (CNMC) mined and processed Cu-Co ore in the Zambian copper belt through 4 majority-owned subsidiaries namely NFCA, CLM, CCS and Sino-Metal leach Zambia Ltd.

### **Zimbabwe**

Aquarius Platinum Ltd in the year 2011 produced 86 tonnes of cobalt from its Mimosa platinum mines. The concentrates were refined by Impala in South Africa.

## **FOREIGN TRADE**

### **Exports**

Exports of cobalt and alloys including waste and scrap also increased moderately to 298 tonnes in 2011-12 as against 281 tonnes in the previous year. Out of the total exports in 2011-12, exports of cobalt and alloys were 285 tonnes and those of cobalt waste & scrap were 13 tonnes. Exports were mainly to Netherlands & USA (40% each), Rep. of Korea (11%) and U.K (4%) (Tables - 4 to 7).

### **Imports**

Imports of cobalt ores and concentrates decreased to 1,196 tonnes in 2011-12 from 5,041 tonnes in the previous year. Imports were mainly from Congo Rep. of (35%), Congo Democratic Rep. of (14%) and China (13%). Imports of cobalt and alloys increased to 994 tonnes in 2011-12 from 726 tonnes in the previous year. Imports in 2011-12 were mainly from Norway (26%), USA (12%), Belgium (9%) and China & Zambia (8% each). However, imports of cobalt in the form of cobalt powder, other articles and unwrought cobalt also took place (Tables-8 to 12).

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**Table – 4 : Exports of Cobalt Ores & Conc.  
(By Countries)**

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
<b>All Countries</b>	<b>51</b>	<b>3741</b>	-	-
China	51	3740	-	-
Netherlands	++	1	-	-
Other countries	-	-	-	-

**Table – 5 : Exports of Cobalt & Alloys  
(Including Waste and Scrap)  
(By Countries)**

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
<b>All Countries</b>	<b>281</b>	<b>450877</b>	<b>298</b>	<b>424072</b>
Netherlands	111	195621	113	176828
USA	112	160895	115	142878
Korea, Rep. of	25	53612	32	58552
UK	5	2620	16	20453
Germany	++	195	12	6277
Indonesia	1	2538	5	5151
Italy	++	183	1	3523
Malaysia	3	4209	1	3344
Sri Lanka	++	70	1	2630
Portugal	++	750	1	2622
Other countries	24	30184	1	1814

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

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
<b>All Countries</b>	<b>275</b>	<b>448270</b>	<b>285</b>	<b>414093</b>
Netherlands	111	195621	113	176828
USA	112	160408	114	141637
Korea, Rep. of	25	53612	32	58552
UK	5	2620	10	14680
Indonesia	1	2538	5	5151
Italy	++	183	1	3523
Malaysia	3	4209	1	3344
Germany	++	195	6	3311
Sri Lanka	++	70	1	2630
Portugal	++	750	1	2622
Other countries	18	28064	1	1815

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

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
<b>All Countries</b>	<b>6</b>	<b>2607</b>	<b>13</b>	<b>9979</b>
UK	-	-	6	5772
Germany	-	-	6	2966
USA	++	486	1	1241
Other countries	6	2121	-	-

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

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
<b>All Countries</b>	<b>5041</b>	<b>1515404</b>	<b>1196</b>	<b>1251501</b>
Congo, Rep. of	1109	1059679	417	357290
Congo, Dem. Rep. of	3719	370673	168	227913
China	-	-	151	209880
Ivory Coast/Cote D Ivoire	-	-	54	73894
Indonesia	-	-	25	33729
Tanzania Rep.	-	-	27	21859
Germany	-	-	3	3390
Iran	-	-	15	815
Australia	-	-	++	8
Unspecified	93	41033	336	322723
Other countries	120	44019	-	-

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**Table – 9: Imports of Cobalt & Alloys  
(By Countries)**

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
<b>All Countries</b>	<b>726</b>	<b>1573775</b>	<b>994</b>	<b>1911680</b>
Norway	30	67523	259	522990
USA	83	199181	115	256790
Belgium	75	175067	91	222073
China	23	50671	79	138175
Zambia	107	161706	79	132686
Canada	77	146093	42	75787
France	42	215900	22	69589
Korea, Rep. of	-	-	43	62173
UK	40	82158	24	48920
Unspecified	14	25691	124	155426
Other countries	235	449785	116	227071

**Table – 10 : Imports of Cobalt Powders  
(By Countries)**

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
<b>All Countries</b>	<b>149</b>	<b>359282</b>	<b>154</b>	<b>386247</b>
Belgium	58	144068	66	163087
USA	28	71459	31	80880
China	14	29493	23	55263
France	6	17262	8	21390
UK	16	35108	5	10031
Indonesia	-	-	4	9243
Italy	-	-	4	8778
Finland	7	17702	3	7885
Canada	1	1738	4	6645
Japan	2	6218	1	4792
Other countries	17	36234	5	18253

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**Table – 11 : Imports of Cobalt (Other Articles)  
(By Countries)**

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
<b>All Countries</b>	<b>332</b>	<b>726642</b>	<b>426</b>	<b>729503</b>
USA	55	127543	80	168538
China	5	12647	49	66697
Zambia	67	106397	40	65439
Korea, Rep. of	-	-	40	56581
Belgium	10	14461	24	54738
France	30	184070	12	41721
UK	23	44558	14	28763
Canada	28	54271	13	25819
Germany	1	7800	5	17955
Unspecified	-	-	121	150052
Other countries	113	174895	28	53200

**Table – 12 : Imports of Cobalt (Unwrought)  
(By Countries)**

Country	2010-11		2011-12	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
<b>All Countries</b>	<b>245</b>	<b>487851</b>	<b>414</b>	<b>795930</b>
Norway	30	67523	259	522990
Zambia	40	55309	39	67246
Canada	48	90084	25	43323
Australia	17	30678	23	38776
South Africa	-	-	20	30357
Congo, People's Rep. of	44	91551	11	19631
China	4	8531	7	16215
UK	1	2492	5	10126
USA	++	179	4	7371
France	6	14569	2	6478
Other countries	55	126935	19	33417



## FUTURE OUTLOOK

India does not have any primary cobalt resources. Two possible secondary sources are nickel-bearing laterite deposits in Odisha and declining copper slag produced by HCL, which have been under R&D studies for commercial applications over the years. Recovery in small quantities of cobalt from wastes like cutting-tool scrap and beta-naphtha cake from the zinc industry was carried out in the late 1980s. In addition, conversion of spent catalysts from plants producing TPA, DMT and the oxo-alcohols was also carried out as a regular source of cobalt though, these were mostly recycled. The cobalt refiners in India have catered to the market for chemical applications or where the cobalt metal or salt is dissolved and converted to cobalt oxide for cutting tools application.

Due to specialised nature of applications and difficulty in substitution, the future demand of cobalt is likely to follow an increasing trend.

The bulk demand for cobalt in the world would be in cemented carbides used in cutting tools, catalysts in petrochemical industry, drying agent in paint industry and in super alloys used mainly in jet engine parts. The demand of cobalt is supposed to go up with use of super-alloys in civil aviation, catalysts for gas-to-liquid production of synthetic liquid fuels, rechargeable batteries for hybrid electric vehicles, cellular telephones, aerospace and energy generation industries which use cobalt-bearing super alloy gas turbine engine parts. During the last year, global demand for lithium-ion batteries has grown rapidly as a result of the increase in demand for mobile phones, portable PCs & electronic devices. In India, cobalt will find major applications in metallurgy due to greater demand in special alloys/ super alloys and in cutting tools and as an alloy in permanent magnets. Cobalt powder demand will continue to grow for bonded tools in diamond industry.