

MOLYBDENUM



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MOLYBDENUM

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**GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES**

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11 Molybdenum

Molybdenum (Mo) is a refractory metal used principally as an alloying agent in steel, cast iron & superalloys to enhance strength and wear and corrosion resistance. It does not occur in nature in free state. Usually, it is found in chemically combined form with other elements. Molybdenite (MoS_2) is the principal ore of molybdenum. About two-thirds of global molybdenum production is as by-product of copper mining and only about one-third is obtained from primary molybdenum mines. In India, by-product concentrates of molybdenum are produced intermittently from uranium ore of Jaduguda mine belonging to Uranium Corporation of India Ltd (UCIL) in Jharkhand. The internal demand for molybdenum and its products is met mostly through imports.

RESERVES/RESOURCES

India continues to lack in several critical minerals and one of them is molybdenum. In India, molybdenum is associated generally with copper, lead and zinc ores. Rakha copper deposit in Jharkhand contains 45 to 48 ppm molybdenum. Malanjkhand copper deposit in Madhya Pradesh contains 0.04% recoverable molybdenum. Dariba-Rajpura lead-zinc deposit in Rajasthan contains molybdenum besides bismuth, arsenic and cadmium. The multimetal deposit at Umpyrtha in Khasi and Jaintia Hills, Meghalaya, reportedly contains molybdenum in association with copper, lead and tungsten. Molybdenum deposit in Karadikuttam in Madurai district, Tamil Nadu, contains 0.02 to 0.14% recoverable molybdenum.

As per NMI database, based on UNFC System, the resources of molybdenum ore in the country as on 1.4.2015 have been estimated at 19.37 million tonnes containing about 12,668 tonnes MoS_2 . The above resources of ore are located in Tamil Nadu (10 million tonnes), Madhya Pradesh (8 million tonnes) and Karnataka (1.32 million tonnes) (Table-1).

EXPLORATION & DEVELOPMENT

The exploration and development details are given in the review on EXPLORATION AND DEVELOPMENT in "GENERAL REVIEW".

USES

Molybdenum is a versatile alloying agent for alloy steel, cast iron, nickel, cobalt and titanium alloys. For desired metallurgical properties, it is used in the form of molybdic oxide or ferro-molybdenum. It is used in different proportions for imparting desired properties, such as increased strength, hardness and resistance to corrosion, temperature and chipping. It also finds application in permanent magnet alloys. As a refractory metal, it is used in many electrical and electronic components and as resistance element in electric furnaces and other equipment which are operated at extremely high temperatures. Its non-metallurgical uses are in lubricants, catalysts, pigments, as an additive in oil and greases, in aerosol sprays, in reducing surface friction and as an antiwear and antifriction agent in plastics. Molybdenum plays a vital role in the energy industry and it may become an increasingly essential factor in green technology.

MINING

Molybdenum concentrate is produced intermittently from uranium ore at Jaduguda mine of UCIL.

SUBSTITUTES

There is little substitution for molybdenum in its major application, viz, as an alloying element in steel and cast irons. Owing to the availability and versatility of molybdenum, industry has sought to develop new materials that benefit from the alloying properties of the metal. Potential substitutes for molybdenum include chromium, vanadium, niobium (columbium) and boron in alloy steels; tungsten in tool steels; graphite, tungsten and tantalum for refractory materials in high temperature electric furnaces and chrome-orange, cadmium-red and organic-orange pigments for molybdenum orange.

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**Table – 1 : Reserves/Resources of Molybdenum as on 1.4.2015
(By Grades/States)**

(In tonnes)

Grade/State	Reserves		Remaining Resources					Total Resources (A+B)
	Total (A)		Pre-feasibility STD221	Measured STD331	Indicated STD332	Inferred STD333	Reconnaissance STD334	
All India : Total								
Ore	-	1500000		36000	569304	17098594	167800	19371698
Contained MoS₂	-	1050		83	287	11198.03	50.34	12668.37
By States								
Karnataka								
Ore	-	-	-	-	-	1320900	-	1320900
Contained MoS ₂	-	-	-	-	-	1718.7	-	1718.7
Madhya Pradesh								
Ore	-	-	-	-	-	8000000	-	8000000
Contained MoS ₂	-	-	-	-	-	5020	-	5020
Tamil Nadu								
Ore	-	1500000		36000	569304	7777694	167800	10050798
Contained MoS ₂	-	1050		83	287	4459.33	50.34	5929.67

Figures rounded off.

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INDUSTRY AND CONSUMPTION

Usually, molybdenum is used in the form of roasted concentrates, oxide or ferro-molybdenum in the defence industries. HCL has installed a pilot plant for producing molybdenum concentrate from copper ore containing 0.3% Mo at Rakha mine, East Singhbhum district, Jharkhand. However, molybdenum recovery at Rakha mine is not found economical.

Molybdenum is used chiefly in the form of ferro-molybdenum. The production of ferro-molybdenum increased from 1,459 tonnes in 2015-16 to 1,603 tonnes in 2016-17. Alloy steel industry alone accounted for about 66% consumption followed by iron & steel (29%) and foundry (4%). The data on production and consumption of ferro-molybdenum are given in Tables- 2 and 3, respectively.

Non-ferrous Technology Development Centre at the Defence Metallurgical Research Laboratory, Hyderabad has a pilot plant for producing molybdenum powder. Institute of Minerals and Materials Technology (formerly RRL), Bhubaneswar, is carrying out basic research on recovery of molybdenum from spent catalysts.

Table – 2 : Production of Ferro-molybdenum 2012-13 to 2016-17

(In tonnes)	
Year	Production
2012-13	1076
2013-14	1231
2014-15	1295
2015-16	1459
2016-17 (P)	1603

Source: Monthly Statistics of Mineral Production, March 2017, IBM.

TRADE POLICY

As per Foreign Trade Policy, 2015-2020, imports of molybdenum ores & concentrates under Exim code 2613 and molybdenum & articles thereof under Exim code 8102 are allowed free, except molybdenum waste & scrap (under ITC-HS Code No. 8102 9700) which are restricted.

Table – 3 : Consumption* of Ferro-molybdenum, 2013-14 to 2015-16 (By Industries)

(In tonnes)			
Industry	2013-14	2014-15	2015-16 (P)
All Industries	672	708	1449
Alloy steel	435	472	950
Electrode	20	17	17
Foundry	57	59	59
Iron & steel	160	160	423

(* Includes actual reported consumption and/or estimates made wherever required and due to paucity of data, coverage may not be completed).

WORLD REVIEW

The world reserves of molybdenum are 17 million tonnes, located mainly in China (49%), USA (16%), , Peru (13%), Chile (11%) and Russia (6%) (Table-4).

The world production of molybdenum in terms of metal content decreased to 2.92 lakh tonnes in 2015 from 3.03 lakh tonnes in 2014. China with 45% production was the main producer of molybdenum in the world followed by USA (19%), Chile (18%), Mexico (4%) and Armenia (2%) in 2015 (Table-5).

Table – 4 : World Reserves of Molybdenum (By Principal Countries)

(In '000 tonnes of molybdenum content)	
Country	Reserves
World: Total (rounded)	17000
Armenia	150
Argentina	100
Canada	150
Chile	1800
China ^(e)	8300
Iran	43
Mexico	130
Mongolia	160
Peru	2200
Russia ^(e)	1000
Turkey	100
USA	2700
Uzbekistan ^(e)	60

Source: Mineral Commodity Summaries, January, 2018.

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**Table – 5 : World Mine Production of Molybdenum
(By Principal Countries)**

Country	(In tonnes of metal content)		
	2013	2014	2015
World: Total (rounded)	280500	302803	292081
Armenia	5934	6022	5324
Canada	8952	8681	4189
Chile	38715	48770	52398
China	122265	128538 ^e	130000 ^e
Iran	3470	4000 ^e	4000 ^e
Mexico	12562	14370	12279
Russia	3605	3114 ^e	3100 ^e
USA	61000	68200 ^e	56300 ^e
Other countries	23997	21108	24491

Source: World Mineral Production, 2011-15,

Canada

At its Gibraltar Mine in south-central British Columbia, Taseko Mines Ltd produced 437 tonnes of molybdenum in 2015, a 59% decrease from the 1,057 tonnes of molybdenum produced in 2014. Molybdenum production decreased because the company idled its molybdenum circuit at the end of July. There was no molybdenum production in the fourth quarter of 2015.

Chile

Antofagasta plc (London, United Kingdom) announced that in 2015, by-product molybdenum production at its Los Pelambres Mine was 10,100 tonnes, a 28% increase compared with 7,900 tonnes of molybdenum produced in 2014. Antofagasta anticipated 2016 molybdenum production to be approximately 8,000 to 9,000 tonnes. Antofagasta also announced that it was constructing a new molybdenum plant at Centinela. The feasibility study was ongoing in 2015 and the project was delayed to preserve cash in 2016. The new plant was expected to produce approximately 2,400 tonnes per year of molybdenum concentrate and was expected to be completed in 2017.

CODELCO, the state-controlled copper and molybdenum producer, announced that it produced 27,700 tonnes of molybdenum in 2015 compared with 30,600 tonnes in 2014. CODELCO

attributed the 10% decrease in molybdenum production to lower output from the Chuquicamata Division. The Chuquicamata open pit mine produced 12,640 tonnes of molybdenum in 2015, a 14% decrease compared with the 14,620 tonnes of molybdenum produced in 2014.

CODELCO, through its subsidiary MOLYB Ltd, continued building its molybdenum concentrate treatment plant, located in Mejillones, Antofagasta Region. The plant was scheduled to begin operations in the second half of 2016 and was expected to produce 16,500 tonnes per year of molybdenum trioxide and 30,000 tonnes per year of sulphuric acid. It was also expected to produce rhenium as a by-product.

The Sierra Gorda project, in the Antofagasta Region in northern Chile, was a joint venture among KGHM International Ltd, Sumitomo Metal Mining Co., Ltd, and Sumitomo Corp. under the company Sierra Gorda SCM. The Sierra Gorda Mine produced 7,000 tonnes of molybdenum concentrate in 2015. The company expected to complete a ramp up phase in 2016 and was expected to produce between 18,100 and 22,600 tonnes per year of molybdenum concentrate.

China

Liaoning Hongda Molybdenum Industry Co. Ltd suspended all molybdenum production in 2015. Inner

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Mongolia Zhongxi Mining Co. Ltd announced a 2,000 tonnes decrease in production of molybdenum concentrate during the first 3 quarters of 2015. This was offset by Yichun Luming molybdenum mine increasing its production by 12,000 tonnes. Jinduicheng Molybdenum Co. Ltd (JDC) and China Molybdenum Co., Ltd both announced that their 2015 molybdenum production levels remained unchanged from 2014 levels. JDC operated the Jinduicheng open pit molybdenum mine, two concentrators, one smelter, and two processing plants in Jinduicheng, Hua County, in northwest Shaanxi Province.

Mexico

Southern Copper Corp. reported that its La Caridad Mine, in northeastern Sonora, produced 10,040 tonnes of molybdenum concentrate in 2015 compared with 10,800 tonnes of molybdenum concentrate in 2014. Southern Copper also announced that the new coppermolybdenum concentrator at its Buenavista Mine was expected to reach full capacity in the second quarter of 2016. The concentrator has a production capacity of 188,000 tonnes per year of copper and 2,600 tonnes per year of molybdenum concentrate. The Buenavista Mine is located 40 kilometers (km) south of the Arizona U.S.- Mexican border.

Peru

The Cerro Verde Mine of FCX is an open pit copper and molybdenum mining complex, 16 km southwest of Arequipa. The Cerro Verde expansion project commenced operations in September 2015. The project expanded the concentrator facilities to a capacity of approximately 6,800 tonnes per year of molybdenum concentrate. Production in 2015 was approximately 3,200 tonnes of molybdenum concentrate compared with 5,000 tonnes in 2014.

Southern Copper's Toquepala Mine, located in southern Peru, 870 km from Lima, produced 7,923 tonnes of molybdenum concentrate in 2015 compared with 7,000 tonnes of molybdenum concentrate in 2014. Southern Copper announced that the construction permit for the Toquepala expansion project was approved in April. The Toquepala expansion project was expected to increase annual molybdenum production by 3,100 tonnes in 2018. Southern Copper's Cuajone Mine in southern Peru produced 4,440 tonnes of molybdenum concentrate in 2015 compared with 4,000 tonnes of molybdenum concentrate in 2014.

FOREIGN TRADE

Exports

Exports of molybdenum ores & concentrates were 22 tonnes in 2016-17. In 2016-17 exports were solely to Oman. Exports of molybdenum ores & concentrates were increased to 45 tonnes in 2015-16 from 24 tonnes in 2014-15. Exports of molybdenum and scrap decreased to 12 tonnes in 2015-16 from 55 tonnes in 2014-15. Exports were mainly to USA (17%) (Tables-6 to 8).

Imports

Imports of molybdenum ores & concentrate were 7,138 tonnes in 2016-17. Imports were mainly from Chile (32%), Thailand (22%), Mexico (13%) and USA (8%). Imports of molybdenum ores & concentrates were decreased slightly to 7511 tonnes in 2015-16 from 8093 tonnes in 2014-15. Imports of molybdenum and scrap decreased marginally to 351 tonnes in 2015-16 from 373 tonnes in the 2014-15. China (72%), Austria (14%) and USA (9%) were the main suppliers (Tables- 9 to 11).

**Table – 6 : Exports of Molybdenum Ores & Conc.
(By Countries)**

Country	2016-17 (P)	
	Qty (t)	Value (₹'000)
All Countries	22	1004
Oman	22	1004

**Table – 7 : Exports of Molybdenum Ores & Conc.
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	24	17801	45	2199
Oman	3	160	45	2198
UK	-	-	++	1
Netherlands	20	15112	-	-
Israel	1	2529	-	-

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**Table – 8 : Exports of Molybdenum & Scrap
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	55	188842	12	152054
Germany	3	28761	1	33078
USA	14	37861	2	18975
Japan	1	25703	1	18230
Italy	++	1327	1	17491
Austria	1	16159	1	15739
Singapore	1	23069	++	12853
Poland	1	8808	1	7668
Belgium	1	12406	1	6681
Egypt	1	5722	1	5029
Bangladesh	++	1678	1	2500
Other countries	32	27348	2	13810

**Table – 9 : Imports of Molybdenum Ores & Conc.
(By Countries)**

Country	2016-17 (P)	
	Qty (t)	Value (₹'000)
All Countries	7138	5442499
Chile	2274	1748715
Thailand	1541	1323969
Mexico	910	605988
USA	578	399108
Korea, Rep. Of	513	345157
Netherlands	421	375146
Iran	254	252403
Belgium	245	190455
Vietnam	94	47753
China	90	76895
Germany	84	26932
Other countries	135	49977

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**Table – 10 : Imports of Molybdenum Ores and Conc.
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	8093	8646302	7511	4903722
Chile	3026	3090846	3682	2145557
Thailand	1860	2321799	1399	1149674
Mexico	666	827643	821	491385
USA	853	938463	575	415476
Netherlands	72	63981	345	220820
Korea, Rep. of	220	230794	227	180572
Belgium	173	131643	163	117530
China	521	707914	74	57663
UAE	20	5448	51	26688
Vietnam	51	59230	40	19952
Other countries	631	268541	134	78405

**Table –11 : Imports of Molybdenum & Scrap
(By Countries)**

Country	2014-15		2015-16 (P)	
	Qty (t)	Value (₹'000)	Qty (t)	Value (₹'000)
All Countries	373	1268948	351	1148229
China	249	676696	254	721187
Austria	77	408887	50	252263
USA	23	93413	30	109368
Germany	8	36883	6	24163
UK	2	4314	6	12676
Hong Kong	1	4667	1	7753
Hungary	++	6004	++	5304
Japan	1	3416	1	4574
Netherlands	++	168	2	3433
France	-	-	1	3095
Other countries	12	34500	++	4413

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FUTURE OUTLOOK

The principal uses of molybdenum in chemical applications and as catalyst and as an additive in steel manufacturing, most importantly alloy and stainless steel, are expected to continue. Molybdenum plays a vital role in the energy industry and it may become increasingly important factor in environment protection technology, where it is used in high strength steels for automobiles to reduce weight and improve fuel economy and safety. Molybdenum-based catalysts have a number of

important applications in Petroleum and Plastic Industries.

A major use is in the hydrodesulfurization of petroleum, petrochemicals and coal-derived liquids. Production of ultra-low-sulfur diesel fuels is expected to more than double the amount of molybdenum used in oil refineries. Molybdenum not only allows for economical fuel refining, it also contributes to a safer environment through lower sulfur emissions. Analysts expect global demand for catalysts to continue to increase as there are no practical alternatives to molybdenum in many of its catalytic applications.