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MOLYBDENUM

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GOVERNMENT OF INDIA
MINISTRY OF MINES
INDIAN BUREAU OF MINES

Indira Bhavan, Civil Lines,
NAGPUR – 440 001

PHONE/FAX NO. (0712) 2565471
PBX : (0712) 2562649, 2560544, 2560648
E-MAIL : cme@ibm.gov.in
Website: www.ibm.gov.in

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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 resistivity to wear & corrosion. 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 though is endowed with rich mineral wealth, there are several critical minerals that it lacks 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 as on 1.4.2015, based on UNFC System, the resources of molybdenum ore in the country 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, if any, are covered in the Review on "Exploration & Development" under "General Reviews".

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.

SUBSTITUTES

There is hardly any substitution for molybdenum in its major application, viz, as an alloying element in steel and cast irons. Owing to the non-availability of molybdenum, there was an apparent need to develop new materials that could be a suitable subsititute vis-a-vis 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.

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	Total (B)	
All India : Total								
Ore	**-**	**1500000**	**36000**	**569304**	**17098594**	**167800**	**19371698**	**19371698**
Contained MoS_2	**-**	**1050**	**83**	**287**	**11198.03**	**50.34**	**12668.37**	**12668.37**
By States								
Karnataka								
Ore	-	-	-	-	1320900	-	1320900	1320900
Contained MoS_2	-	-	-	-	1718.7	-	1718.7	1718.7
Madhya Pradesh								
Ore	-	-	-	-	8000000	-	8000000	8000000
Contained MoS_2	-	-	-	-	5020	-	5020	5020
Tamil Nadu								
Ore	-	1500000	36000	569304	7777694	167800	10050798	10050798
Contained MoS_2	-	1050	83	287	4459.33	50.34	5929.67	5929.67

Figures rounded off

INDUSTRY AND CONSUMPTION

Usually, molybdenum is used in the form of roasted concentrates, oxide or ferro-molybdenum in the Defence industries. The production of ferro-molybdenum decreased from 1,205 tonnes in 2017-18 to 1,003 tonnes in 2018-19 (Table-2).

Non-ferrousTechnology 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, has been undertaking basic research on recovery of molybdenum from spent catalysts.

Table – 2 : Production of Ferromolybdenum 2014-15 to 2018-19

(In tonnes)

Year	Production
2014-15	1295
2015-16	1459
2016-17	1603
2017-18 (R)	1205
2018-19 (P)	1003

Source: *Monthly Statistics of Mineral Production, March 2019, IBM.*

Moly Metal LLP, a leading manufacturer of Molybdenum alloys ferromolybdenum (FeMo) and molybdenum disulphide (MoS_2), commenced production in 2007 at a new manufacturing plant in the U.T. of Daman. RUBAMIN, a Gujarat-based Company reportedly has a capacity of 1,500 tonnes per annum sodium molybdate and 800 tonnes per annum ammonium molybdate both of which are derivates of molybdenum.

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.

WORLD REVIEW

The world reserves of molybdenum are at 18 million tonnes, located mainly in China (46%), Peru (16%), USA (15%), Chile (8%) and Russia (6%) (Table-3).

Table – 3 : World Reserves of Molybdenum (By Principal Countries)

(In '000 tonnes of molybdenum content)

Country	Reserves
World: Total (rounded)	**18000**
Argentina	100
Armenia (e)	150
Canada	100
Chile	1400
China(e)	8300
Iran(e)	43
Mexico	130
Mongolia	210
Peru	2900
Russia(e)	1000
Turkey(e)	700
USA	2700
Uzbekistan(e)	60

Source: *USGS Mineral Commodity Summaries, January 2020.*

The world mine production of molybdenum in terms of metal content decreased to 2.76 lakh tonnes in 2018 from 2.90 lakh tonnes in 2017. China with 36% production was the main producer of molybdenum in the world followed by Chile (22%), USA (15%), Peru (10%) and Mexico (7%) in 2018 (Table-4).

To give a generalised view of the development in various countries, the countrywise description sourced from available publication, i.e., Minerals Yearbook of USGS 2016 is furnished below.

Canada

Teck Resources Ltd announced that its Highland Valley Mine in south-central British Columbia produced 3,490 tonnes of molybdenum concentrate in 2016, a 75% increase from the 2,000 tonnes of molybdenum concentrate produced in 2015. The Company attributed the large increase to higher grade of ore. The Company targetted molybdenum production be approximately 4,100 to 4,300 tonnes/year in 2017, before declining to approximately 3,200 tonnes/year from 2018 to 2020.

At its Gibraltar Mine in south-central British Columbia, Taseko Mines Ltd produced 430 tonnes of molybdenum in 2016, a slight decrease from the 437 tonnes of molybdenum produced in 2015.

The molybdenum circuit at Gibraltar restarted in September 2016 after being idle since the third quarter of 2015.

Chile

In 2015, Amerigo Resources Ltd produced only 44 tonnes of molybdenum at its Minera Valle Central processing facility in central Chile because the production was reported only in the first quarter of 2015. Molybdenum production restarted in August 2016, with an annual production of 230 tonnes of molybdenum.

Antofagasta plc announced that the by-product molybdenum production at its Los Pelambres Mine in 2016 was 7,100 tonnes, which showed a decline of 30% when compared to 10,100 tonnes of molybdenum produced in 2015. Antofagasta also announced that it was constructing a new molybdenum plant at Centinela.

Table – 4 : World Mine Production of Molybdenum

(By Principal Countries)

(In tonnes of metal content)

Country	2016	2017	2018
World: Total (rounded)	**283000**	**290000**	**276000**
China	129357	117104	99390
Chile	55834	62454	60248
USA	36200	40700	42000[e]
Peru	25757	28141	28034
Mexico	11896	13985	20265
Iran	6975	7767	8000[e]
Armenia	5438	5886	5666
Canada	2883	4941	5131
Mongolia	2431	2639	2571
Russia	3359	3227	2400
Other countries	2479	2723	2392

***Source**: World Mineral Production, 2014-18, BGS*
e:- Estimated

The new plant was expected to produce approximately 2,400 tonnes/year of molybdenum concentrate, and construction was expected to commence in 2017.

Corporación Nacional del Cobre de Chile (CODELCO), the state-controlled copper and molybdenum producer, announced that it produced 30,600 tonnes of molybdenum in 2016 as against 27,700 tonnes in 2015. CODELCO attributed the 10% increase in molybdenum production to higher output from the Chuquicamata open pit mine.

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 GordaSCM.

The Sierra Gorda Mine produced 10,000 tonnes of molybdenum concentrate in 2016, a 52% increase when compared to the 6,600 tonnes of molybdenum concentrate produced in 2015. The increase was mainly attributed to the mine and processing plant remaining in the ramp-up phase during the first half of 2015.

Argentina

Minera Alumbrera Ltd began molybdenum production at the Alumbrera copper-gold-molybdenum mine in northern Argentina in 2008 when it commissioned a molybdenum recovery circuit. The Alumbrera Mine is a Joint Venture among Glencore plc (50%), Goldcorp Inc. (37.5%) and Yamana Gold Inc. (12.5%). According to the Company, all molybdenum produced from the mine was exported to Chile.

Mexico

Grupo Mexico S.A.B. de C.V. (Grupo Mexico) reported that its La Caridad Mine, in northeastern Sonora, produced 9,900 tonnes of molybdenum concentrate in 2016 as compared to 10,040 tonnes of molybdenum concentrate produced in 2015. Grupo Mexico also reported that it completed the $3.5 billion investment programme at Buenavista del Cobre on time and $100 million below budget. The new copper-molybdenum concentrator has a production capacity of 1,88,000 tonnes/year of copper and 2,600 tonnes/year of molybdenum concentrate. In 2016, it produced 1,600 tonnes of molybdenum concentrate. The Buenavista Mine is located 40 km south of the border between the United States (Arizona) and Mexico.

Peru

The Cerro Verde Mine (FCX has a 53.56% ownership interest) is an open pit copper and molybdenum mining complex, 16 km southwest of Arequipa. According to FCX, the Cerro Verde expansion project commenced operations in September 2015 and achieved capacity operating rates during the first quarter of 2016. Production in 2016 was approximately 9,500 tonnes of molybdenum concentrate as against 3,200 tonnes of molybdenum concentrate produced in 2015.

Grupo Mexico also announced that it continued to work on the Toquepala expansion project in southern Peru. The Toquepala expansion project was expected to increase annual molybdenum production by 3,100 tonnes. The project was expected to be complete in the second quarter of 2018.

Chinalco Mining Corporation International announced that, as of June 2016, the molybdenum hydrometallurgical project at the Toromocho copper-molybdenum operation had not started production. The Toromocho project is located in central Peru in the core of the Morochocha mining district. The molybdenum operation had a production capacity of 25.1 t/d of molybdenum over the life of the mill and would be Peru's first molybdenum-processing facility.

China

Chinese molybdenum production took place predominantly in Hebei, Henan, and Shaanxi Provinces and Nei Mongol Autonomous Region. China has a large number of small-scale mining operations that were very susceptible to changes in prices and also were able to increase or decrease production quickly during price fluctuations. In 2016, the decrease in Chinese production was attributed to a new round of environmental inspections that was launched by the Chinese Government.

The environmental inspections have forced some producers to shut down permanently or upgrade their facilities to comply with stricter environmental standards. Jinduicheng Molybdenum Co. Ltd announced that it reduced production in 2016. Inner Mongolia Zhongxi Mining Co. Ltd announced that their 2016 production levels remained unchanged.

Armenia

The Zangezur Copper-Molybdenum Combine continued to produce molybdenum at Kajaran Mine. According to Cronimet Mining AG, the Kajaran Mine is the leading copper and molybdenum mine in Armenia. Zangezur Copper-Molybdenum shareholders are Cronimet Mining (60%), Pure Iron Plant OJSC (15%), Armenian Molybdenum Production Ltd (12.5%), and Zangezur Mining Ltd (12.5%).

In 2016, Vallex Group (Yerevan) completed the construction of its copper and molybdenum ore processing plant near the Kashen deposit and started processing its first ore. The deposit contained an estimated 56 Mt of ore with 0.49% copper content and 0.006% molybdenum content. Vallex has been working on the Kashen Mine since 2012 and has invested approximately $120 million to bring it to the first phase of production. Vallex also owns the Teghut copper and molybdenum mine and concentrator plant located in the Tumanyan region in northern Armenia. According to the company, the Teghut Mine has been producing approximately 380 tonnes/year of molybdenum concentrate.

FOREIGN TRADE

Exports

Exports of molybdenum ores & concentrates decreased sharply by 14% to 6 tonnes in 2018-19 from 7 tonnes in 2017-18. Exports were solely to Malaysia. Exports of molybdenum and scrap increased sharply by 76% to 517 tonnes in 2018-19 from 294 tonnes in 2017-18. Exports were mainly to Netherlands (79%) and Germany (18%) (Tables-5 & 6).

Imports

Imports of molybdenum ores & concentrates increased moderately by 20% to 11,028 tonnes in 2018-19 from 9,169 tonnes in 2017-18. Imports were mainly from Chile (45%), Thailand (18%), Netherlands (10%), USA(6%), Republic of Korea (3%) and UAE (2%). Imports of molybdenum and scrap also increased marginally by 25% to 493 tonnes in 2018-19 from 393 tonnes in the 2017-18. Imports were mainly from China (58%), Austria (19%), Netherlands (10%), USA (5%) and Hong Kong (4%) (Tables-7 & 8).

Table – 5 : Exports of Molybdenum Ores & Conc.
(By Countries)

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**7**	**1923**	**6**	**81**
Malaysia	-	-	6	81
UAE	2	891	-	-
Egypt	++	770	-	-
Oman	5	261	-	-

Figures rounded off

Table – 6 : Exports of Molybdenum & Scrap (By Countries)

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**294**	**180111**	**517**	**281068**
Netherlands	215	46901	409	124962
Austria	2	16719	4	48600
Germany	69	34388	92	32905
China	++	8800	2	15037
USA	1	10255	1	10150
Poland	1	8654	1	8658
Pakistan	++	2108	1	8370
Egypt	1	3600	1	5600
Belgium	++	3075	++	4853
Bangladesh	++	1500	1	2933
Other countries	5	44111	5	19000

Figures rounded off

Table – 7 : Imports of Molybdenum Ores and Conc. (By Countries)

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**9169**	**8149457**	**11028**	**13606783**
Chile	3298	2667607	4962	6089700
Thailand	2211	2423961	1933	3178550
Netherlands	693	639758	1080	1051223
USA	830	638918	698	857459
Korea, Rep. of	760	595367	326	488426
UAE	-	-	270	384710
Switzerland	-	-	223	360397
Turkey	-	-	201	345915
Iran	409	485872	137	235404
China	114	123425	103	145231
Other countries	854	574549	1095	469768

Figures rounded off

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

Country	2017-18 (R)		2018-19 (P)	
	Qty (t)	Value (`'000)	Qty (t)	Value (`'000)
All Countries	**393**	**1197142**	**493**	**1698725**
China	265	664096	285	887244
Austria	86	364799	95	421319
USA	23	82933	27	130467
Netherlands	++	56	48	107359
Hong Kong	1	5467	21	53070
Germany	5	22165	4	27932
Singapore	1	8121	3	24083
UK	6	11054	5	15646
France	3	30581	++	9630
Japan	++	202	++	7580
Other countries	3	7668	5	14395

Figures rounded off

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.

Molybdenum-based catalysts are extensively used in the hydrodesulfurisation of petroleum, petrochemicals and coal-derived liquids. Production of ultra-low sulphur diesel fuels is expected to rise and therefore more than double the amount of molybdenum could find application in oil refineries. Molybdenum not only allows for economical fuel refining, but also contributes to a safer environment by lowering sulphur emissions. Analysts expect the global demand for catalysts to continue to increase as there are no practical alternatives to molybdenum in many of its catalytic applications. Besides, the need for Companies to reduce carbon dioxide emissions from coal-fired power stations will require plants to run at higher temperatures, resulting in greater demand for higher grade molybdenum-bearing steels.