



# 2015 Minerals Yearbook

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## MOLYBDENUM [ADVANCE RELEASE]

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# MOLYBDENUM

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Molybdenum is contained in various minerals, but only molybdenite ( $\text{MoS}_2$ ) is suitable for the industrial production of marketable molybdenum products. Although molybdenum is marketed largely as ferromolybdenum ( $\text{FeMo}$ ) or as roasted concentrates [molybdic oxide ( $\text{MoO}_3$ , called  $\text{MoX}$ )], published production data refer to mine production, which is the recoverable molybdenum content of raw concentrates. Depending upon the minerals contained in the ore body, mines can be grouped into primary mines, where the recovery of  $\text{MoS}_2$  is the sole objective, or byproduct mines where the recovery of copper-bearing ores is the primary objective and  $\text{MoS}_2$  provides additional economic value. In the United States, total mine production of molybdenum concentrate decreased by 31% to 47,400 metric tons (t) in 2015 compared with 68,200 t in 2014. Molybdenum concentrate production at primary molybdenum mines continued at two U.S. operations accounting for 44% of total U.S. molybdenum concentrate production. Molybdenum concentrate production at byproduct mines continued at eight U.S. operations, accounting for 56% of total U.S. molybdenum concentrate production. World mine production of molybdenum concentrate was estimated at 235,000 t in 2015 compared with the revised 268,000 t in 2014 (table 10). The U.S. share of world production was 20% in 2015. Reported U.S. consumption of primary molybdenum products, not including molybdenum concentrates, decreased by 10% in 2015 compared with that of 2014 (table 3).

Molybdenum is a refractory metallic element used principally as an alloying agent in cast iron, steel, and superalloys to enhance hardenability, strength, toughness, and wear- and corrosion-resistance. To achieve desired metallurgical properties, molybdenum, primarily in the form of  $\text{MoX}$  or  $\text{FeMo}$ , is commonly used in combination with or added to chromium, manganese, nickel, niobium (columbium), tungsten, or other alloy metals. The versatility of molybdenum in enhancing a variety of alloy properties has ensured it a significant role in contemporary industrial technology, which increasingly requires materials that can sustain high stress, expanded temperature ranges, and highly corrosive environments. Significant uses of molybdenum are as a refractory metal and in numerous chemical applications, including catalysts, lubricants, and pigments. Molybdenum has become increasingly important in green technology, particularly in the manufacture of biofuels, catalysts, ethanol, solar panels, and wind turbines.

U.S. molybdenum reserves were estimated to have been about 2.7 million metric tons (Mt) in 2015, about 31% of world molybdenum reserves. About 90% of U.S. reserves occur in large, low-grade porphyry molybdenum deposits mined or anticipated to be mined primarily for molybdenum and in low-grade porphyry copper deposits as an associated metal sulfide.

These deposits are in Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Utah.

## Production

Domestic primary and byproduct molybdenum mine production data were derived from three separate voluntary surveys by the U.S. Geological Survey. These surveys are “Molybdenum Ore and Concentrate” (annual), “Molybdenum Concentrate” (monthly), and “Molybdenum Concentrates and Molybdenum Products” (monthly). Surveys were sent to all 10 U.S. operations (two primary molybdenum mines, eight byproduct mines) that currently produce molybdenum concentrates and products from ore, and all responded, representing 100% of U.S. concentrate production reported in table 1.

As of December 31, 2015, U.S.-rated capacity for mines and mills was estimated to have decreased 14% to 85,900 metric tons per year (t/yr) of contained metal. Rated capacity is defined as the maximum quantity of product that can be produced in a period of time on a normally sustainable long-term operating rate, based on the physical equipment of the plant and given acceptable routine operating procedures involving energy, labor, maintenance, and materials. Capacity included plants that were temporarily closed but could be brought into production within a short period of time with minimal capital expenditure.

Primary molybdenum production continued at the Climax Mine and the Henderson Mine in Colorado. Freeport-McMoRan Copper & Gold Inc. (FCX) operated the Henderson underground mine and the Climax open pit mine. Both mines produced high-purity, chemical-grade molybdenum concentrates, which were further processed into value-added molybdenum chemical products. Production from both mines in 2015 totaled 21,770 t of molybdenum, compared with 23,130 t in 2014 (Freeport-McMoRan Copper & Gold Inc., 2016a, p. 47). The Climax Mine restarted commercial operations in May 2012 and included a 25,000-metric-ton-per-day (t/d) mill facility. Molybdenum production from Climax totaled 10,400 t in 2015, a 10% increase from the 9,500 t produced in 2014 (Freeport-McMoRan Copper & Gold Inc., 2016b, p. 15–16). The Henderson operation consisted of a large underground mining complex that fed a 32,000-t/d concentrator. Henderson had the capacity to produce 18,140 t/yr of molybdenum concentrate. The majority of the molybdenum concentrate produced at Henderson was shipped to FCX’s Fort Madison, IA, processing facility. Henderson announced that it revised its operating plans to incorporate a 65% reduction in operating rates to accelerate its debt reduction plans (Freeport-McMoRan Copper & Gold Inc., 2016b, p. 13).

The Thompson Creek Mine in Idaho was placed on care-and-maintenance status in 2014 and did not produce any

molybdenum in 2015. The Ashdown Mine in Nevada and the Questa Mine in New Mexico remained closed.

Thompson Creek Metals Co. Inc. (TCMC) continued to operate its metallurgical roasting facility in Langeloth, PA. The facility has the capacity to roast 16,300 t/yr of raw molybdenum concentrate and the capacity to process more than 4,000 t/yr of MoX into FeMo. The Langeloth facility also processed nonmolybdenum catalysts for various customers, primarily in the food industry (Thompson Creek Metals Co. Inc., undated b).

Byproduct mines included the Bagdad, Mission, Morenci, Pinto Valley, and Sierrita Mines in Arizona; the Continental Pit Mine in Montana; the Robinson Mine in Nevada; and the Bingham Canyon Mine in Utah (table 2). In the case of byproduct molybdenum recovery at a copper mine, all mining costs associated with molybdenum concentrate production are allocated to the primary metal (copper). In 2015, byproduct molybdenite recovery accounted for approximately 56% of the U.S. molybdenum concentrate production.

The Bagdad operation of FCX included a 75,000-t/d concentrator that produced copper and molybdenum concentrates, as well as a pressure-leach plant that processed molybdenum concentrate. Bagdad produced approximately 4,080 t of molybdenum concentrate in both 2014 and 2015 (Freeport-McMoRan Copper & Gold Inc., 2016a, p. 10).

The Morenci operation of FCX consisted of two concentrators capable of milling 115,000 t/d of ore to produce copper and molybdenum concentrates. FCX owns an 85% undivided interest in Morenci, with the remaining 15% owned by Sumitomo Metal Mining Arizona, Inc. Morenci's production, including the joint-venture partner's share, totaled 3,600 t of molybdenum concentrate, compared with the 453 t produced in 2014 (Freeport-McMoRan Copper & Gold Inc., 2016a, p. 11).

The Sierrita operation of FCX included a 102,000-t/d concentrator that produced copper and molybdenum concentrates. It also had molybdenum facilities consisting of a leaching circuit, two molybdenum roasters, and a packaging facility. The molybdenum facilities processed concentrate from Sierrita, other FCX mines, and third-party sources. Molybdenum concentrate production at Sierrita in 2015 was 9,500 t, a 13% decrease compared with 10,900 t of molybdenum concentrate produced in 2014 (Freeport-McMoRan Copper & Gold Inc., 2016b, p. 14).

FCX's Chino Mine is an open pit copper-mining complex located in southwestern New Mexico's Grant County. Chino did not produce molybdenum in 2015 but did produce approximately 450 t of molybdenum concentrate in 2014 (Freeport-McMoRan Copper & Gold Inc., 2016b, p. 16).

Rio Tinto plc (London, United Kingdom) reported that molybdenum concentrate production at its Bingham Canyon Mine (operated by its subsidiary Kennecott Utah Copper Corp.) was 7,600 t of molybdenum concentrate compared with 11,500 t of molybdenum concentrate produced in 2014. Production in 2015 was affected by ongoing recovery from the 130-Mt landslide on the northeast wall of the mine that occurred in April 2013. Work to stabilize the wall continued in 2015, and the company expected production volumes to recover as this work is completed in 2016 and 2017 (Rio Tinto plc, 2016, p. 34).

Mineral Park Inc., a subsidiary of Mercator Minerals Ltd. (Vancouver, British Columbia, Canada) announced that it was placing its mill and Mineral Park Mine near Kingman, AZ, on care-and-maintenance status as of December 29, 2014 (Metal Bulletin, 2015).

## Consumption

Statistics on consumption of molybdenum in end-use applications by U.S. metal consumers were developed from the voluntary "Consolidated Consumers Survey." For this survey, molybdenum consumers were canvassed on a monthly or annual basis. Reported consumption and stocks data in tables 1 and 3 include estimates to account for nonrespondents.

In 2015, U.S.-reported consumption of molybdenum contained in concentrate for roasting decreased compared with that of 2014. Reported consumption of molybdenum contained in concentrate was withheld to avoid disclosing company proprietary data. Domestic mine production of molybdenum concentrate was roasted, exported for conversion, or purified to lubricant-grade MoS<sub>2</sub>. MoX was the leading form of molybdenum used by industry, particularly in making stainless steel. Superalloy industry consumption decreased in 2015 compared with that of 2014 (table 3).

Metallurgical applications dominated reported molybdenum use in 2015, accounting for approximately 88% of 2015 total reported consumption. In 2015, FeMo accounted for 21% of the molybdenum-bearing materials used to make steel (not including tool steel, which was withheld) (table 3). Nonmetallurgical applications included catalysts, chemicals, lubricants, and pigments. The dominant nonmetallurgical use was in catalysts, principally catalysts related to petroleum refining.

## Stocks

At yearend 2015, producer plus consumer industry stocks increased compared with yearend 2014 stocks. Inventories of molybdenum in concentrate at mines and plants increased (table 1). Stocks of molybdenum in FeMo, MoX, metal powders, and other products decreased compared with stocks of 2014 (table 3).

## Prices

In 2015, the average monthly price for domestic MoX, as published by CRU Group, ranged from \$4.625 to \$9.422 per pound in 2015, compared with \$9.538 to \$14.747 per pound in 2014. The average monthly price for domestic FeMo ranged from \$6.050 to \$10.775 per pound of molybdenum content, compared with \$11.389 to \$19.063 per pound reported in 2014 (fig. 1). Both FeMo and MoX prices continued to decrease in 2015 until December 2015, when both FeMo and MoX prices increased slightly. Prices have not been this low since early 2003; the average annual MoX price for 2003 was \$5.34 per pound.

## Foreign Trade

Molybdenum enters into international trade largely in raw and roasted concentrates and FeMo. U.S. exports of

molybdenum ore and concentrates (including roasted and other concentrates) were 78% of total U.S. molybdenum concentrate production in 2015. Exports of molybdenum ore and concentrates totaled approximately 36,800 t with 49% of this total going to the Netherlands. The Netherlands features prominently in international trade of molybdenum concentrates and molybdenum-containing products, both as a transiting and warehouse location and as the location for one of Climax Molybdenum Co.'s processing facilities in Rotterdam.

In 2015, molybdenum-containing exports (excluding molybdenum ore and concentrates) collectively totaled approximately 5,310 t (gross weight) valued at \$135 million (tables 4, 6). Imports for consumption of all molybdenum-containing products collectively totaled approximately 31,200 t (gross weight) valued at \$323 million (table 9).

## World Review

World molybdenum reserves and production capacity were concentrated in a few countries. In 2015, world mine output was estimated to have been 235,000 t (molybdenum contained in concentrate), of which, in descending order of production, China, Chile, the United States, Peru, Mexico, and Armenia provided about 94% (table 10).

According to the International Molybdenum Association, global molybdenum consumption in 2015 decreased to 229,700 t compared with the record high of 253,600 t in 2014. The leading consumer of molybdenum in 2015 continued to be China, where consumption decreased to 80,600 t in 2015 from 91,600 t in 2014. Europe was the second leading consumer at 60,100 t in 2015 compared with 65,000 t in 2014 (S & P Global Platts, 2016).

**Armenia.**—The Zangezur Copper-Molybdenum Combine was expected to increase total ore production by 10% in 2016. A second ball mill started operation in 2015. Ore production at the mine was 18.2 Mt in 2015 and the company expected to produce 20.1 Mt in 2016. The company's shareholders are Cronimet Mining AG (60%), Pure Iron Plant OJSC (15%), Armenian Molybdenum Production Ltd. (12.5%), and Zangezur Mining Ltd. (12.5%) (Armenpress, 2016).

**Canada.**—Thompson Creek Metals Co. Inc., along with joint-venture partner, Sojitz Moly Resources Inc., placed the Endako molybdenum mine on care-and-maintenance status in July 2015 owing to weak molybdenum prices (Thompson Creek Metals Co. Inc., undated a).

At its Gibraltar Mine in south-central British Columbia, Taseko Mines Ltd. produced 437 t of molybdenum in 2015, a 59% decrease from the 1,057 t 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 (Taseko Mines Ltd., 2016, p. 4–5).

**Chile.**—In 2015, Amerigo Resources Ltd. produced only 44 t of molybdenum at its Minera Valle Central (MVC) processing facility compared with 263 t in 2014 because molybdenum was only produced in the first quarter of 2015. In 2016, the company expects no molybdenum production owing to prevailing low molybdenum prices (Amerigo Resources Ltd., 2016a). Amerigo processed tailings from El Teniente's Colihues tailings pond as well as fresh tailings from the mine's concentrator. The plant

extracted copper from tailings discharged from Corporación Nacional del Cobre de Chile's (CODELCO's) El Teniente concentrators. The tailings were then returned to El Teniente's tailings disposal system. The MVC facility has a capacity of 175,000 t/d and processed 58 Mt of tailings in 2014 (Amerigo Resources Ltd., 2016b, p. 12–13).

Antofagasta plc (London, United Kingdom) announced that 2015 byproduct molybdenum production at its Los Pelambres Mine was 10,100 t, a 28% increase compared with 7,900 t of molybdenum produced in 2014. Antofagasta anticipated 2016 molybdenum production to be approximately 8,000 to 9,000 t (Antofagasta plc, 2016, p. 4). 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 t/yr of molybdenum concentrate and was expected to be completed in 2017 (Antofagasta plc, 2016, p. 2, 3, 17, 48).

CODELCO, the state-controlled copper and molybdenum producer, announced that it produced 27,700 t of molybdenum in 2015 compared with 30,600 t 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 t of molybdenum in 2015, a 14% decrease compared with the 14,620 t of molybdenum produced in 2014 (Corporación Nacional del Cobre de Chile, 2016, p. 71).

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 t/yr of molybdenum trioxide and 30,000 t/yr of sulfuric acid. It was also expected to produce rhenium as a byproduct (Corporación Nacional del Cobre de Chile, 2016, p. 107).

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 t of molybdenum concentrate in 2015. The company expected to complete a rampup phase in 2016 and was expected to produce between 18,100 and 22,600 t/yr of molybdenum concentrate (KGHM Polska Miedz S.A., 2016, p. 99, 101).

**China.**—Liaoning Hongda Molybdenum Industry Co. Ltd. suspended all molybdenum production in 2015. Inner Mongolia Zhongxi Mining Co. Ltd. announced a 2,000-t 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 t. Jinduicheng Molybdenum Co. Ltd. (JDC) and China Molybdenum Co., Ltd. both announced that their 2015 molybdenum production levels remained unchanged from 2014 levels (Tungsten & Molybdenum Monthly, 2016, p. 11). JDC operated the Jinduicheng open pit molybdenum mine, two concentrators, one smelter, and two processing plants in Jinduicheng, Hua County, in northwest Shaanxi Province.

**Korea, Republic of.**—From 2010 to 2014, NMC Resource Corp. produced molybdenum at the Moland Mine, located 170 km southeast of Seoul. According to the company, the

main crushing circuit was installed underground to reduce noise and dust, and the tailings are trucked to a nearby cement plant to be used as raw material, eliminating the need for a tailings pond (NMC Resource Corp., 2014, p. 11). In the first quarter of 2015, Dong Won Corp., a significant shareholder of the company, acquired all outstanding securities of NMC (Marketwired, 2015).

**Mexico.**—Southern Copper Corp. reported that its La Caridad Mine, in northeastern Sonora, produced 10,040 t of molybdenum concentrate in 2015 compared with 10,800 t of molybdenum concentrate in 2014 (Southern Copper Corp., undated). Southern Copper also announced that the new copper-molybdenum 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 t/yr of copper and 2,600 t/yr of molybdenum concentrate. The Buenavista Mine is located 40 kilometers (km) south of the Arizona U.S.-Mexican border (Southern Copper Corp., 2016, p. 6)

**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 t/yr of molybdenum concentrate. Production in 2015 was approximately 3,200 t of molybdenum concentrate compared with 5,000 t in 2014 (Freeport-McMoRan Copper & Gold Inc., 2016a, p. 39).

Southern Copper's Toquepala Mine, located in southern Peru, 870 km from Lima, produced 7,923 t of molybdenum concentrate in 2015 compared with 7,000 t of molybdenum concentrate in 2014 (Southern Copper Corp., undated). 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 t in 2018. Southern Copper's Cuajone Mine in southern Peru produced 4,440 t of molybdenum concentrate in 2015 compared with 4,000 t of molybdenum concentrate in 2014 (Southern Copper Corp., 2016, p. 5–6, 8, 20).

## Outlook

The principal uses for molybdenum are expected to continue to be in catalysts and chemicals and as an additive in steel manufacturing, most importantly alloy and stainless steel. Molybdenum plays a vital role in the energy industry, and it may become an increasingly important factor in environmental 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 the petroleum and plastics 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 (Roskill Information Services Ltd., 2012, p. 305). 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. 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. Growth in molybdenum use is expected to continue in stainless steels and full alloy steels mainly in the consumer product and transportation industries (Roskill Information Services Ltd., 2016, p. 1–2).

In 2015, global consumption of molybdenum decreased by 9% from the previous year (International Molybdenum Association, 2015; CPM Group, 2015). This decrease was mainly attributed to a slowdown in China as well as a weaker demand for tubular goods from oil-producing countries (Roskill Information Services Ltd., 2016, p. 1). New and expanded molybdenum byproduct capacity at copper operations in the early 2010s led to oversupply by 2015, despite the efforts of many primary molybdenum producers to cut production. A number of mine closures in 2014 and 2015, including the North-American-based Thompson Creek Mine, Endako Mine (TCMC), and Mineral Park Mine (Mercator), reduced global molybdenum supply by over 10,000 t; however, this loss of molybdenum was offset by the Sierra Gorda Mine in Chile as well as the Yichun Luming Mine in China.

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TABLE 1  
SALIENT MOLYBDENUM STATISTICS<sup>1</sup>

(Metric tons of contained molybdenum)

	2011	2012	2013	2014	2015
United States:					
Concentrate:					
Production	63,700	60,400 <sup>r</sup>	61,000	68,200	47,400
Shipments	62,800	60,200 <sup>r</sup>	68,100	71,900 <sup>r</sup>	50,500
Reported consumption <sup>2</sup>	W	W	W	W	W
Imports for consumption	14,700 <sup>r</sup>	12,000	13,100	15,800	12,900
Exports	47,200	43,500	48,600	60,500	36,800
Stocks, December 31:					
Concentrate, mine and plant	3,520	W	W	W	W
Product producers <sup>3</sup>	W	W	W	W	W
Consumers	1,810	1,770	1,820	2,010	1,880
Total	5,330	1,770	1,820	2,010	1,880
Primary products:					
Production	W	W	W	W	W
Shipments	W	W	W	W	W
Reported consumption	19,100	19,400	18,600	19,500 <sup>r</sup>	17,600
Imports for consumption	6,450	7,830	7,190	9,510	5,210
World, mine production	264,000 <sup>r</sup>	256,000	258,000	268,000 <sup>r</sup>	235,000 <sup>e</sup>

<sup>e</sup>Estimated. <sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Molybdenum concentrates roasted to make molybdenum oxide.

<sup>3</sup>Includes ammonium, calcium, and sodium molybdate; briquets; ferromolybdenum; molybdenum hexacarbonyl; molybdenum metal; molybdenum pentachloride; molybdic acid; pellets; phosphomolybdic disulfide; and technical and purified molybdic oxide.

TABLE 2  
MOLYBDENUM-PRODUCING MINES IN THE UNITED STATES IN 2015

State and mine	County	Operator	Source of molybdenum
Arizona:			
Bagdad	Yavapai	Freeport-McMoRan Copper & Gold Inc.	Copper-molybdenum ore, concentrated.
Mission Complex	Pima	ASARCO LLC <sup>1</sup>	Do.
Morenci	Greenlee	Freeport-McMoRan Copper & Gold Inc.	Do.
Pinto Valley	Gila	Capstone Mining Corp.	Do.
Sierrita	Pima	Freeport-McMoRan Copper & Gold Inc.	Do.
Colorado:			
Climax	Lake	do.	Molybdenum ore, concentrated.
Henderson	Clear Creek	do	Do.
Montana, Continental Pit	Silver Bow	Montana Resources	Copper-molybdenum ore, concentrated.
Nevada, Robinson	White Pine	Robinson Nevada Mining Company <sup>2</sup>	Do.
Utah, Bingham Canyon	Salt Lake	Kennecott Utah Copper LLC <sup>3</sup>	Do.

Do., do. Ditto.

<sup>1</sup>Wholly owned subsidiary of Grupo México, S.A.B. de C.V.

<sup>2</sup>Wholly owned subsidiary of KGHM International Ltd.

<sup>3</sup>Wholly owned subsidiary of Rio Tinto plc.

TABLE 3  
U.S. REPORTED CONSUMPTION, BY END USES, AND CONSUMER STOCKS OF MOLYBDENUM MATERIALS<sup>1</sup>

(Kilograms of contained molybdenum)

End use	Molybdic oxides	Ferromolybdenum <sup>2</sup>	Ammonium and sodium molybdate	Molybdenum scrap	Other	Total
2014:						
Steel:						
Carbon	W	192,000	--	--	W	192,000
High-strength low-alloy	W	110,000	--	--	--	110,000
Stainless and heat-resisting	2,190,000	715,000	--	(3)	131,000	3,030,000
Full alloy	3,590,000	3,160,000	--	--	W	6,750,000
Tool	607,000	W	--	(3)	--	607,000
Total	6,380,000	4,180,000	--	--	131,000	10,700,000
Cast irons (gray, malleable, ductile iron)	W	346,000	--	--	W	346,000
Superalloys	668,000	W	--	(3)	1,040,000	1,710,000
Alloys (other than steels, cast irons, superalloys):						
Welding materials (structural and hard-facing)	--	39,900 <sup>r</sup>	--	--	W	39,900 <sup>r</sup>
Other alloys	2,600	70,900	--	--	33,000	107,000
Mill products made from metal powder <sup>4</sup>	W	--	--	--	W	W
Cemented carbides and related products <sup>5</sup>	--	--	--	--	77	77
Chemical and ceramic uses:						
Pigments	W	--	8,220	--	--	8,220
Catalysts	937,000	--	(3)	--	W	937,000
Other	--	--	--	--	W	W
Miscellaneous and unspecified uses:						
Lubricants	--	--	--	--	176,000	176,000
Other	1,080,000	110,000	(3)	(3)	4,270,000	5,460,000
Grand total	9,070,000	4,740,000 <sup>r</sup>	8,220	--	5,660,000	19,500,000
Stocks, December 31	644,000	373,000 <sup>r</sup>	3,950	(6)	(6)	2,010,000
2015:						
Steel:						
Carbon	W	W	--	--	--	W
High-strength low-alloy	W	106,000	--	--	--	106,000
Stainless and heat-resisting	2,170,000	682,000	--	(3)	W	2,850,000
Full alloy	3,240,000	2,170,000	--	--	W	5,410,000
Tool	607,000	W	--	(3)	--	607,000
Total	6,020,000	2,960,000	--	--	W	8,980,000
Cast irons (gray, malleable, ductile iron)	W	330,000	--	--	W	330,000
Superalloys	485,000	W	--	(3)	1,080,000	1,570,000
Alloys (other than steels, cast irons, superalloys):						
Welding materials (structural and hard-facing)	--	W	--	--	W	W
Other alloys	1,410	100,000	--	--	W	102,000
Mill products made from metal powder <sup>4</sup>	--	--	--	--	W	W
Cemented carbides and related products <sup>5</sup>	--	--	--	--	77	77
Chemical and ceramic uses:						
Pigments	W	--	(3)	--	--	W
Catalysts	W	--	(3)	--	W	W
Other	--	--	--	--	W	W
Miscellaneous and unspecified uses:						
Lubricants	--	--	--	--	152,000	152,000
Other	1,680,000	364,000	10,500	(3)	4,370,000	6,430,000
Grand total	8,190,000	3,750,000	10,500	--	5,600,000	17,600,000
Stocks, December 31	600,000	357,000	5,970	(6)	(6)	1,880,000

<sup>r</sup>Revised. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified uses: Other." -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Includes calcium molybdate.

<sup>3</sup>Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified uses: Other" under "Other."

<sup>4</sup>Includes ingot, wire, rod, and sheet.

<sup>5</sup>Includes construction, mining, oil and gas, and metal working machinery.

<sup>6</sup>Withheld to avoid disclosing company proprietary data; included in "Total."

TABLE 4  
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY<sup>1</sup>

Product and country	HTS <sup>2</sup> code	2014		2015	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Oxides and hydroxides, gross weight: <sup>3</sup>	2825.70.0000				
Belgium		612	\$12,700	418	\$6,160
Brazil		161	3,250	197	2,570
Canada		283	3,440	26	280
Estonia		--	--	36	417
Germany		2	54	4	84
Korea, Republic of		18	368	26	462
Kuwait		98	2,170	245	5,280
Mexico		129	2,430	116	1,490
Netherlands		270	5,930	154	1,540
Turkey		140	2,490	72	1,050
Other (9 countries)		28 <sup>f</sup>	663 <sup>f</sup>	4	125
Total		1,740	33,500 <sup>f</sup>	1,300	19,400
Molybdates, all, gross weight: <sup>4</sup>	2841.70.0000				
Canada		381	5,210	369	3,630
Germany		(5)	19	100	1,320
Japan		64	962	83	1,310
Mexico		407	6,010	462	6,680
Netherlands		526	6,180	756	6,340
Other (34 countries)		218 <sup>f</sup>	3,740 <sup>f</sup>	248	2,970
Total		1,600	22,100 <sup>f</sup>	2,020	22,300
Ferromolybdenum, contained weight: <sup>4,6</sup>	7202.70.0000				
Canada		564	17,600	485	13,400
Colombia		(5)	18	1	29
Denmark		(5)	26	1	37
Mexico		27	686	82	1,700
Vietnam		(5)	6	(5)	6
Total		591 <sup>f</sup>	18,400	569	15,100
Molybdenum, other, gross weight: <sup>3,7</sup>	Various <sup>8</sup>				
Austria		174	19,300	127	7,690
Belgium		(5)	24	29	778
Canada		105	4,610	80	3,100
China		95	7,320	101	7,830
Germany		80	4,140	92	4,640
Israel		63	4,910	87	6,850
Japan		103	5,160	104	5,380
Korea, Republic of		161	24,000	139	15,900
Taiwan		74	3,260	117	8,320
United Kingdom		202	9,430	110	5,660
Other (52 countries)		266 <sup>f</sup>	15,500 <sup>f</sup>	195	11,800
Total		1,320	97,700 <sup>f</sup>	1,180	77,900

<sup>f</sup>Revised. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Harmonized Tariff Schedule of the United States.

<sup>3</sup>Presentation of annual data is based on the quantities (gross weight or contained weight) of the ten leading countries in 2015.

<sup>4</sup>Presentation of annual data is based on the quantities (gross weight or contained weight) of the five leading countries in 2015.

<sup>5</sup>Less than ½ unit.

<sup>6</sup>Ferromolybdenum contains about 60% to 65% molybdenum.

<sup>7</sup>Includes powder, unwrought, waste and scrap, wire, wrought, and other.

<sup>8</sup>Includes HTS codes 8102.10.0000, 8102.94.0000, 8102.95.0000, 8102.96.0000, 8102.97.0000, and 8102.99.0000.

Source: U.S. Census Bureau.

TABLE 5  
U.S. EXPORTS OF MOLYBDENUM ORE AND CONCENTRATES  
(INCLUDING ROASTED AND OTHER CONCENTRATES), BY COUNTRY<sup>1,2</sup>

Country	2014		2015	
	Quantity (metric tons of contained Mo)	Value (thousands)	Quantity (metric tons of contained Mo)	Value (thousands)
Belgium	11,000	\$199,000	3,910	\$61,200
Canada	2,210	51,500	1,690	32,000
China	1,430	24,200	477	6,830
India	498	12,400	252	3,750
Japan	6,480	146,000	2,900	45,400
Korea, Republic of	1,320	27,200 <sup>r</sup>	1,350	20,100
Mexico	7,060	185,000	2,530	55,800
Netherlands	17,300	343,000	18,100	275,000
United Kingdom	11,200	215,000	5,110	78,600
Vietnam	60	1,420	274	5,110
Other (15 countries)	1,990 <sup>r</sup>	37,600 <sup>r</sup>	249	3,430
Total	60,500 <sup>r</sup>	1,240,000	36,800	587,000

<sup>r</sup>Revised.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Presentation of annual data is based on the quantities (gross weight or contained weight) of the ten leading countries in 2015.

Source: U.S. Census Bureau.

TABLE 6  
U.S. EXPORTS OF MOLYBDENUM PRODUCTS<sup>1</sup>

Item	HTS <sup>2</sup> code	2014			2015		
		Gross weight (metric tons)	Contained Mo (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained Mo (metric tons)	Value (thousands)
Molybdenum ore and concentrates, roasted	2613.10.0000	NA	27,600	\$565,000	NA	18,100	\$282,000
Molybdenum ore and concentrates, other	2613.90.0000	NA	32,900	678,000	NA	18,700	305,000
Molybdenum chemicals:							
Oxides and hydroxides	2825.70.0000	1,740	NA	33,500	1,300	NA	19,400
Molybdates, all	2841.70.0000	1,600	NA	22,100 <sup>r</sup>	2,020	NA	22,300
Ferromolybdenum	7202.70.0000	857 <sup>r</sup>	592	18,400	815	569	15,100
Molybdenum powders	8102.10.0000	269	NA	11,900	191	NA	7,470
Molybdenum unwrought, bars and rods	8102.94.0000	41	NA	1,880	36	NA	1,320
Molybdenum waste and scrap	8102.97.0000	182	NA	3,970 <sup>r</sup>	206	NA	4,350
Molybdenum wire	8102.96.0000	34	NA	4,040 <sup>r</sup>	27	NA	2,890
Molybdenum, other	Various <sup>3</sup>	795 <sup>r</sup>	NA	75,900 <sup>r</sup>	722	NA	61,900
Total		XX	XX	1,410,000	XX	XX	722,000

<sup>r</sup>Revised. NA Not available. XX Not applicable.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Harmonized Tariff Schedule of the United States.

<sup>3</sup>Includes HTS codes 8102.95.0000 and 8102.99.0000.

Source: U.S. Census Bureau.

TABLE 7  
U.S. IMPORTS FOR CONSUMPTION OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY<sup>1</sup>

Product and country	HTS <sup>2</sup> code	2014		2015	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Oxides and hydroxides, gross weight:	2825.70.0000				
Chile		225	\$4,260	605	\$7,700
China		95	2,000	134	2,110
Germany		2	39	2	49
Korea, Republic of		--	--	3	32
Netherlands		--	--	12	215
Other (3 countries)		126	2,110	(3)	13
Total		448	8,410	756	10,100
Molybdates, all, contained weight: <sup>4</sup>	Various <sup>5</sup>				
Chile		918	15,900	547	5,570
China		244	4,230	459	5,570
Germany		2	69	11	116
Netherlands		2	51	4	91
United Kingdom		21	224	9	150
Other (7 countries)		8 <sup>r</sup>	191 <sup>r</sup>	5	539
Total		1,200 <sup>r</sup>	20,700 <sup>r</sup>	1,040	12,000
Molybdenum orange, gross weight:	3206.20.0020				
Canada		224	1,840	416	1,700
China		1	7	44	215
Colombia		191	1,110	118	579
Germany		10	26	--	--
India		1	7	19	37
Mexico		4	23	12	48
Total		431	3,010	609	2,580
Ferromolybdenum, contained weight: <sup>4,6</sup>	7202.70.0000				
Belgium		89	1,940	55	1,010
Canada		601	11,800	562	8,130
Chile		6,160	117,000	883	13,300
Korea, Republic of		235 <sup>r</sup>	4,430 <sup>r</sup>	740	11,100
United Kingdom		145	5,380	120	2,270
Other (7 countries)		424 <sup>r</sup>	6,370 <sup>r</sup>	19	539
Total		7,650	147,000 <sup>r</sup>	2,380	36,300
Other, gross weight: <sup>7</sup>	Various <sup>8</sup>				
Australia		--	--	10	221
Austria		571	25,000	248	11,600
Canada		597	15,500	257	5,670
China		1,500 <sup>r</sup>	52,200 <sup>r</sup>	889	26,100
Germany		213 <sup>r</sup>	7,940 <sup>r</sup>	161	5,530
Japan		54	2,040	35	881
Korea, Republic of		9	139	11	146
Russia		22	2,590	13	1,360
Taiwan		31	687 <sup>r</sup>	8	438
United Kingdom		87	2,620	43	1,080
Other (20 countries)		228 <sup>r</sup>	7,850 <sup>r</sup>	15	840
Total		3,310 <sup>r</sup>	117,000 <sup>r</sup>	1,690	53,900

<sup>r</sup>Revised. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Harmonized Tariff Schedule of the United States.

<sup>3</sup>Less than ½ unit.

<sup>4</sup>Presentation of annual data is based on the quantities (gross weight or contained weight) of the five leading countries in 2015.

<sup>5</sup>Includes HTS codes 2841.70.1000 and 2841.70.5000.

<sup>6</sup>Ferromolybdenum contains about 60% to 65% molybdenum.

<sup>7</sup>Presentation of annual data is based on the quantities (gross weight or contained weight) of the ten leading countries in 2015.

<sup>8</sup>Includes HTS codes 8102.10.0000, 8102.94.0000, 8102.95.3000, 8102.95.6000, 8102.96.0000, 8102.97.0000, and 8102.99.0000.

Source: U.S. Census Bureau.

TABLE 8  
U.S. IMPORTS OF MOLYBDENUM ORE AND CONCENTRATES (INCLUDING  
ROASTED AND OTHER CONCENTRATES), BY COUNTRY<sup>1</sup>

Country	2014		2015	
	Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
Belgium	41	\$511	--	--
Canada	11,500	152,000	2,840	\$22,600
Chile	3,750 <sup>r</sup>	47,300 <sup>r</sup>	9,910	69,700
China	40	616 <sup>r</sup>	1	25
Japan	(2)	6	--	--
Korea, Republic of	--	--	20	225
Mexico	5,940	85,100 <sup>r</sup>	3,370	49,200
Mongolia	61	845	---	--
Netherlands	63 <sup>r</sup>	993 <sup>r</sup>	--	--
Peru	7,990 <sup>r</sup>	113,000	8,610	64,100
Total	29,400 <sup>r</sup>	400,000 <sup>r</sup>	24,700	206,000

<sup>r</sup>Revised. -- Zero.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9  
U.S. IMPORTS FOR CONSUMPTION OF MOLYBDENUM PRODUCTS<sup>1</sup>

Item	HTS <sup>2</sup> code	2014			2015		
		Gross weight (metric tons)	Contained Mo (metric tons)	Value (thousands)	Gross weight (metric tons)	Contained Mo (metric tons)	Value (thousands)
Molybdenum ore and concentrates, roasted	2613.10.0000	8,260 <sup>r</sup>	5,020 <sup>r</sup>	\$118,000 <sup>r</sup>	6,780	4,050	\$76,400
Molybdenum ore and concentrates, other	2613.90.0000	21,100	10,800	282,000	18,000	8,830	129,000
Molybdenum chemicals:							
Oxides and hydroxides	2825.70.0000	448	NA	8,410	756	NA	10,100
Molybdates, all	Various <sup>3</sup>	1,200	669 <sup>r</sup>	20,700	1,040	578	12,000
Molybdenum orange	3206.20.0020	431	NA	3,010	609	NA	2,580
Ferromolybdenum	7202.70.0000	7,650 <sup>r</sup>	5,110	147,000	2,380	1,610	36,300
Molybdenum powders	8102.10.0000	535 <sup>r</sup>	512 <sup>r</sup>	19,800	232	206	7,560
Molybdenum unwrought, bars and rods	8102.94.0000	1,310 <sup>r</sup>	1,280 <sup>r</sup>	38,400 <sup>r</sup>	682	679	16,500
Molybdenum waste and scrap	8102.97.0000	1,080 <sup>r</sup>	1,050 <sup>r</sup>	31,500 <sup>r</sup>	536	516	11,500
Molybdenum wire	8102.96.0000	14 <sup>r</sup>	NA	2,200 <sup>r</sup>	14	NA	1,860
Molybdenum, other	Various <sup>4</sup>	390 <sup>r</sup>	NA	26,800 <sup>r</sup>	239	NA	18,400
Total		42,400 <sup>r</sup>	XX	698,000 <sup>r</sup>	31,200	XX	323,000

<sup>r</sup>Revised. NA Not available. XX Not applicable.

<sup>1</sup>Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Harmonized Tariff Schedule of the United States.

<sup>3</sup>Includes HTS codes 2841.70.1000 and 2841.70.5000.

<sup>4</sup>Includes HTS codes 8102.95.3000, 8102.95.6000, and 8102.99.0000.

Source: U.S. Census Bureau.

TABLE 10  
MOLYBDENUM: WORLD MINE PRODUCTION, BY COUNTRY<sup>1,2</sup>

(Metric tons of contained molybdenum)

Country <sup>3</sup>	2011	2012	2013	2014	2015 <sup>4</sup>
Armenia	5,745 <sup>r</sup>	6,525 <sup>r</sup>	6,900 <sup>r</sup>	7,162 <sup>r</sup>	7,200
Canada	8,543	8,936	7,956	9,358 <sup>r</sup>	2,287 <sup>4</sup>
Chile	40,889	35,090	38,715	48,770	52,579 <sup>4</sup>
China <sup>c</sup>	103,000	105,000	101,000	92,000 <sup>r</sup>	83,000
Iran	3,365 <sup>r</sup>	3,516 <sup>r</sup>	3,471 <sup>r</sup>	3,494 <sup>r</sup>	3,500
Mexico	10,787	11,366	12,562	14,370	11,327 <sup>4</sup>
Mongolia	1,960	1,904 <sup>r</sup>	1,819 <sup>r</sup>	1,999	2,000
Peru	19,141	16,790	18,140	17,018	20,153 <sup>4</sup>
Russia	6,014	4,939	4,753	4,658 <sup>r</sup>	4,500
Turkey	400 <sup>r</sup>	600 <sup>r</sup>	800 <sup>r</sup>	900 <sup>r</sup>	900
United States	63,700	60,400 <sup>r</sup>	61,000	68,200	47,400 <sup>4</sup>
Uzbekistan	557	522	490 <sup>r</sup>	450 <sup>r</sup>	450
Total	264,000 <sup>r</sup>	256,000	258,000	268,000 <sup>r</sup>	235,000

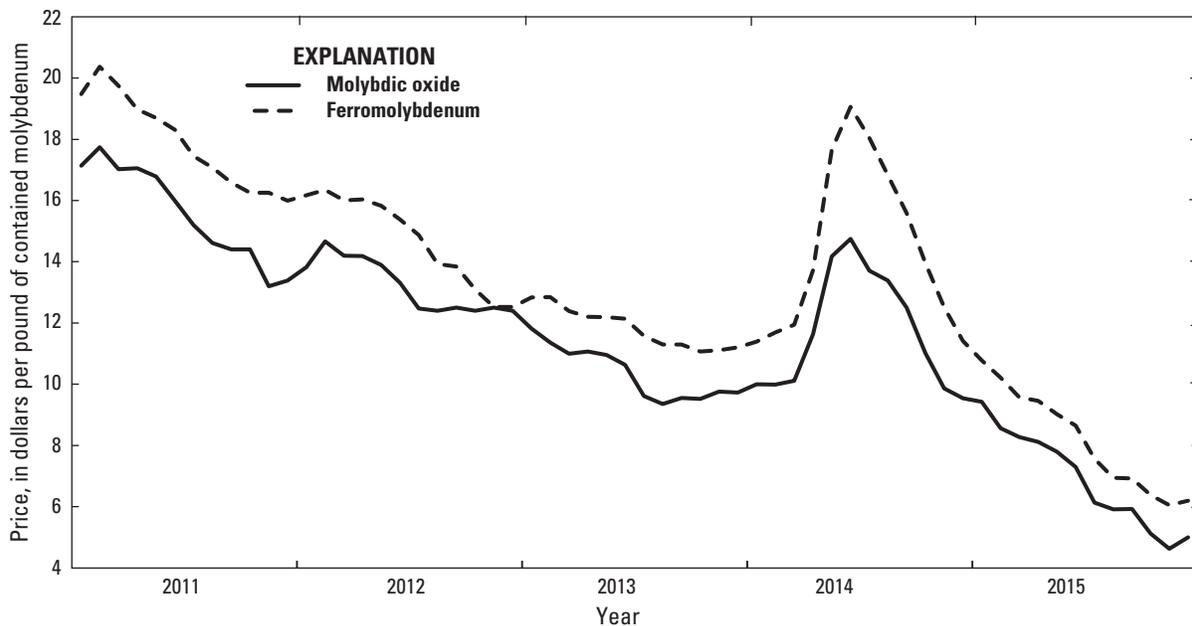
<sup>r</sup>Estimated. <sup>r</sup>Revised.

<sup>1</sup>World totals, U.S. data, and estimated data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Includes data available through August 8, 2016.

<sup>3</sup>In addition to the countries listed, the Republic of Korea, Kyrgyzstan, and Romania are thought to produce molybdenum, but output is not reported quantitatively, and available general information is inadequate to make reliable estimates of output levels.

<sup>4</sup>Reported figure.



**Figure 1.** U.S. average monthly prices for molybdc oxide and ferromolybdenum from January 2011 through December 2015. Source: CRU Group.