



2017 Minerals Yearbook

MOLYBDENUM [ADVANCE RELEASE]

MOLYBDENUM

By Désirée E. Polyak

Domestic survey data and tables were prepared by Raymond I. Eldridge III, statistical assistant.

In the United States, total mine production of molybdenum concentrate increased by 12% to 40,700 metric tons (t) of contained molybdenum in 2017 compared with 36,200 t in 2016 (table 1). World mine production of molybdenum concentrate was 297,000 t of contained molybdenum in 2017 compared with 278,000 t in 2016 (table 10). The U.S. share of world production was 14% in 2017, up from 13% in 2016. Reported U.S. consumption of primary molybdenum products, not including molybdenum concentrates, increased by 10% in 2017 compared with that of 2016 (table 3). U.S. annual averages of monthly average prices also increased in 2017; molybdc oxide (MoO_3 , called MoX) increased by 25%, and ferromolybdenum (FeMo) increased by 26%, compared with the annual average prices in 2016.

Molybdenum is contained in various minerals, but only molybdenite (MoS_2) is suitable for the industrial production of marketable molybdenum products. Although molybdenum is marketed largely as FeMo or as roasted concentrates (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 MoS_2 is the sole objective, or byproduct mines, where the recovery of copper-bearing ores is the primary objective and MoS_2 provides additional economic value.

U.S. molybdenum reserves were estimated to have been about 2.7 million metric tons (Mt) in 2016, about 18% 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.

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 MoX or 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.

Production

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

Molybdenum concentrate production at primary molybdenum mines continued at two U.S. operations, accounting for 36% of total U.S. molybdenum concentrate production. Molybdenum concentrate production at byproduct mines continued at seven U.S. operations, accounting for 64% of total U.S. molybdenum concentrate production.

As of December 31, 2017, rated capacity in the United States for mines and mills was estimated to be 85,900 metric tons per year (t/yr) of contained molybdenum. 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 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. The Climax Mine restarted commercial operations in May 2012 and included a 25,000-metric-ton-per-day (t/d) mill facility. Climax had the capacity to produce approximately 13,600 t/yr of molybdenum. Molybdenum production from Climax totaled 9,070 t in 2017, a 25% increase from the 7,260 t produced in 2016 (Freeport-McMoRan Inc., 2018, p. 13–14).

In response to market conditions, the Henderson Mine operated at reduced rates during 2016 and 2017. The Henderson Mine produced 5,440 t of molybdenum in 2017, a 20% increase compared with the 4,540 t produced in 2016. The Henderson operation consisted of a large underground mining complex that fed a 32,000-t/d concentrator. Henderson had the capacity to produce 15,900 t/yr of molybdenum concentrate. Most of the molybdenum concentrate produced at Henderson was shipped to FCX’s Fort Madison, IA, processing facility (Freeport-McMoRan Inc., 2018, p. 13).

The Thompson Creek Mine in Idaho was placed on care-and-maintenance status in 2014 and did not produce any molybdenum in 2017. 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 had 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 (Langeloth Metallurgical Co., LLC, undated).

Byproduct mines included the Bagdad, 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 2017, byproduct molybdenite recovery accounted for approximately 64% 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 2017 compared with 3,630 t in 2016 (Freeport-McMoRan Inc., 2018, p. 8).

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 a 72% undivided interest in Morenci, with the remaining owned by Sumitomo Metal Mining Arizona, Inc. (15%) and SMM Morenci (13%). Morenci's production, including the joint-venture partners' share, totaled 5,440 t of molybdenum concentrate, compared with 6,800 t produced in 2016 (Freeport-McMoRan Inc., 2018, p. 7).

The Sierrita operation of FCX included a 100,000-t/d concentrator that produced copper and molybdenum concentrates. Sierrita 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 2017 was 6,800 t, a 7% increase compared with 6,350 t of molybdenum concentrate produced in 2016 (Freeport-McMoRan Inc., 2018, p. 10).

Rio Tinto plc (United Kingdom) reported that 2017 molybdenum concentrate production at its Bingham Canyon Mine (operated by its subsidiary Rio Tinto Kennecott) was 5,000 t compared with 2,800 t produced in 2016. Rio Tinto attributed the large increase in molybdenum production to the overall increase of truck productivity, resulting in higher volumes of total material moved compared with 2016 (Rio Tinto plc, 2018, p. 42).

Montana Resources LLP continued molybdenum concentrate production at its Continental Pit Mine in Butte, Montana. Capstone Mining Corp. (Canada) also continued molybdenum concentrate production at its Pinto Valley Mine near Miami, AZ. Capstone produced 64 t of molybdenum concentrate in 2017 (Capstone Mining Corp., 2018, p. 2). Robinson Nevada Mining Co., a wholly owned subsidiary of KGHM International Ltd., continued molybdenum production at its Robinson Mine in White Pine County, NV (KGHM International Ltd., undated).

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 2017, reported U.S. consumption of molybdenum contained in concentrate for roasting increased compared with that of 2016. Reported consumption of molybdenum contained in concentrate was withheld to avoid disclosing company proprietary data (table 1). Domestic mine production of molybdenum concentrate was roasted, exported for conversion, or purified to lubricant-grade MoS₂.

In 2017, reported U.S. consumption of molybdenum contained in concentrate for primary products such as alloys, carbon steel, and stainless steel increased by 10% compared with that of 2016. The leading form of molybdenum used by industry, particularly in making stainless steel, was MoX. Superalloy industry consumption of molybdenum products increased in 2017 compared with that of 2016 (tables 1, 3).

Metallurgical applications dominated reported molybdenum use in 2017, accounting for approximately 88% of 2017 total reported consumption. In 2017, 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. Catalytic applications, principally those related to petroleum refining, constituted the largest uses for molybdenum outside the steel industry and were the most important chemical end uses for molybdenum.

Stocks

At yearend 2017, consumer stocks increased compared with yearend 2016 stocks. Inventories of molybdenum in concentrate at mines and plants increased (table 1). Consumer stocks of molybdenum in FeMo, MoX, metal powders, and other products also increased compared with stocks of 2016 (table 3).

Prices

In 2017, the average monthly price for domestic MoX, as published by CRU Group, ranged from \$7.350 to \$8.788 per pound, compared with \$5.300 to \$7.967 per pound in 2016. In 2017, the average monthly price for domestic FeMo ranged from \$8.731 to \$10.767 per pound of contained molybdenum, compared with \$6.547 to \$8.969 per pound reported in 2016 (fig. 1). Ferromolybdenum has historically commanded a small price premium over MoX as a result of the additional conversion costs incurred during production.

In the first half of 2017, FeMo and MoX prices increased owing to stronger than anticipated molybdenum demand from Chinese steel producers. However, FeMo prices decreased in June and continued to fluctuate until December when FeMo prices increased. Molybdic oxide prices decreased in June but increased again in September and continued to increase in December.

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 America-based Thompson Creek Mine, Endako Mine (TCMC), and Mineral Park Mine (Mercator), reduced global molybdenum supply by more than 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.

Despite the increase in molybdenum prices in 2017, many companies could continue to be deterred from restarting molybdenum production, fearing a return to the low prices of early 2016.

Existing molybdenum producers were expected to contribute most of the additional supply through 2020, particularly from mines located in the United States and China (Roskill Information Services Ltd., 2017, p. 8).

Foreign Trade

Molybdenum enters into international trade largely in raw and roasted concentrates and FeMo. Exports of molybdenum ore and concentrates (both unroasted and roasted) totaled approximately 39,800 t (contained weight) valued at \$592 million with 35% of this total going to the Netherlands (table 5). The Netherlands featured 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 2017, molybdenum-containing exports (excluding molybdates and molybdenum ore and concentrates) collectively totaled approximately 2,200 t (gross weight) valued at \$81 million (table 6). Imports for consumption of all molybdenum-containing products collectively totaled approximately 64,000 t (gross weight) valued at \$680 million (table 9).

In 2017, exports of molybdenum ore and concentrates (both unroasted and roasted) totaled approximately 39,800 t (contained weight) valued at \$592 million (table 6). In 2017, U.S. imports of molybdenum ore and concentrates (both unroasted and roasted) totaled approximately 24,300 t (contained weight), a 63% increase from the 14,900 t imported in 2016 (table 9). This large increase was attributed mainly to the 91% increase of molybdenum ore and concentrate imported from Peru (table 8).

World Review

World molybdenum reserves and production capacity were concentrated in a few countries. In 2017, world mine output was 297,000 t (molybdenum contained in concentrate), of which, in descending order of production, China, Chile, the United States, Peru, and Mexico provided about 93% (table 10).

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

Canada.—Teck Resources Ltd. announced that its Highland Valley Mine in south-central British Columbia produced 4,200 t of molybdenum in concentrate in 2017, a 72% increase from the 2,400 t of molybdenum in concentrate produced in 2016. The company attributed the large increase to higher ore grades. The higher mill-head grade in 2017 was not expected to be repeated in 2018 as the company was expected to process ore from lower grade sections in the Valley and Lornex pits. The company estimated production in 2018 to be approximately 2,300 t of molybdenum in concentrate (Teck Resources Ltd., 2018, p. 18).

At its Gibraltar Mine in south-central British Columbia, Taseko Mines Ltd. produced a record-high 1,200 t of molybdenum in concentrate in 2017, a 178% increase from the 430 t of molybdenum in concentrate produced in 2016. The company attributed the large increase to higher ore grades and mill throughput. The molybdenum circuit at Gibraltar restarted in September 2016 after being idle since the third quarter of 2015 (Taseko Mines Ltd., 2018, p. 3–4).

Chile.—Amerigo Resources Ltd. reported that it produced 730 t of molybdenum in 2017, more than double 2016 production (230 t) at its Minera Valle Central processing facility in central Chile. Amerigo forecast production of 820 t of molybdenum in 2018 (Amerigo Resources Ltd., 2018, p. 1).

Antofagasta plc (United Kingdom) announced that 2017 byproduct molybdenum production at its Los Pelambres Mine was 10,500 t of molybdenum in concentrate, a 48% increase compared with 7,100 t of molybdenum in concentrate produced in 2016. The company attributed the increased production to a higher average ore grade compared with that in 2016. Antofagasta also announced that its new molybdenum plant at the 70%-owned Centinela Mine was expected to produce approximately 1,500 t of molybdenum in concentrate in 2018, following commissioning in early 2018. The Centinela Mine is located 1,350 kilometers (km) north of Santiago in the Antofagasta Region. The Centinela molybdenum plant had a capacity to produce an average of 2,400 t/yr of molybdenum in concentrate. At the end of December 2017, the project was 98% complete with a total cost of \$40 million (Antofagasta plc, 2018, p. 34, 36, 38–39, 47, 195).

Corporación Nacional del Cobre de Chile (CODELCO), the state-controlled copper and molybdenum producer, announced that it produced 28,700 t of molybdenum in 2017 compared with 30,600 t in 2016. CODELCO attributed the 6% decrease in molybdenum production to lower production from the Chuquicamata open pit mine (Corporación Nacional del Cobre de Chile, 2018, p. 1, 3).

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 16,200 t of molybdenum in concentrate in 2017 (KGHM Polska Miedź S.A., 2018, p. 28).

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 susceptible to changes in prices and also were able to quickly increase or decrease production during price fluctuations.

Environmental inspections at molybdenum mines and processing facilities continued in 2017 and disrupted production at a variety of molybdenum producers. Luanchuan Longyu Molybdenum Co. Ltd. closed its mining operation at the end of February 2017 owing to a collapse of its tailing pond. It restarted production at the end of April in order to generate cash to support the required ongoing environmental upgrade work. Several roasting and smelting companies, including Beipiao Wanhong Molybdenum Co. Ltd. and Huludao Dongyue Metals Co. Ltd., also restarted their ferromolybdenum production in June following the completion of environmental inspections in the Liaoning Province (CRU Group, 2017).

Jinduicheng Molybdenum Co. Ltd. announced that it produced 42,500 t of molybdenum concentrate in 2017, an 8% increase compared with the 39,300 t of molybdenum concentrate produced in 2016 (Argus Metals International, 2017). China Molybdenum Co. Ltd. announced that it produced 16,700 t of molybdenum in 2017, a 3% increase from the previous year (Argus Metals International, 2018).

Mexico.—Southern Copper Corp. (a subsidiary of Grupo México S.A.B. de C.V.) reported that it completed a \$3.5 billion investment program at the Buenavista del Cobre mining unit and all of the projects in the program were in full operation. The projects included two molybdenum plants with a combined annual capacity of 4,200 t of molybdenum in concentrate. The first plant was completed in 2013 and the second one in 2016. In 2017, the plants produced 3,140 t of molybdenum in concentrate compared with 1,430 t of molybdenum in concentrate produced in 2016. The Buenavista Mine is 40 km south of the United States-Mexican border (Southern Copper Corp., 2018, p. 42–43). Southern Copper reported that its La Caridad Mine in northeastern Sonora produced 8,980 t of molybdenum in concentrate in both 2016 and 2017 (Southern Copper Corp., 2018, p. 45–46).

Peru.—Teck announced that it produced 3,900 t of molybdenum in concentrate in 2017 at its Antamina copper-zinc mine in Peru, 15% less than that in 2016 as a result of processing less copper-molybdenum ore and more copper-zinc ore during the year. Copper, molybdenum, and zinc production at Antamina can vary significantly from year to year owing to the geology of the deposit and proportion of copper to copper-zinc ore processed. Molybdenum production was expected to decrease to 3,600 t in 2018 but increase to between 5,000 and 5,900 t/yr from 2019 through 2021. The Antamina Mine is in the Andes mountain range, 270 km north of Lima. The Antamina Mine was a joint venture among BHP Billiton plc (33.75%), Glencore plc (33.75%), Teck (22.5%), and Mitsubishi Corp. (10%) (Teck Resources Ltd., 2018, p. 18–19; Wheaton Precious Metals Corp., 2018, p. 86).

The Cerro Verde Mine (FCX had a 53.56% ownership interest) is an open pit copper and molybdenum mining complex, 32 km southwest of Arequipa. According to FCX, production in 2017 was approximately 12,200 t of molybdenum in concentrate compared with 9,500 t of molybdenum in concentrate in 2016 (Freeport-McMoRan Inc., 2018, p. 14–15).

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. Catalysts are estimated to account for more than 70% of chemical uses of molybdenum (Roskill Information Services Ltd., 2017, p. A195). 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. Increase 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., 2017, p. 1–2).

According to the International Molybdenum Association (2018), global molybdenum consumption in 2017 increased to 253,100 t compared with 232,500 t in 2016. The consumption of molybdenum in structural and engineering steel is forecast to remain the leading end use for molybdenum products (Roskill Information Services Ltd., 2017, p. 7).

References Cited

- Amerigo Resources Ltd., 2018, Amerigo announces annual 2017 and Q4-2017 production results: Vancouver, British Columbia, Canada, Amerigo Resources Ltd., January 16, 3 p. (Accessed July 27, 2018, at http://www.amerigoresources.com/_resources/news/nr_2018_01_16.pdf.)
- Antofagasta plc, 2018, Annual report 2017: London, United Kingdom, Antofagasta plc, April 16, 216 p.
- Argus Metals International, 2017, Molybdenum output rises on oil rebound: Argus Media group, Argus Metals International, October 4, 1 p. (Accessed July 11, 2018, via <http://www.argusmedia.com/metals>.)
- Argus Metals International, 2018, China Molybdenum raises metal output in 2017: Argus Media group, Argus Metals International, April 3, 1 p. (Accessed July 11, 2018, via <http://www.argusmedia.com/metals>.)
- Capstone Mining Corp., 2018, Capstone Mining 2017 production results and 2018 operating and capital guidance: Vancouver, British Columbia, Canada, Capstone Mining Corp., January 10. (Accessed September 17, 2018, at http://s2.q4cdn.com/231101920/files/doc_news/2018/01/2017-Q4-Production-and-2018-Guidance-NR-Final.pdf.)
- Corporación Nacional del Cobre de Chile, 2018, Results ending December 31, 2017: Santiago, Chile, Corporación Nacional del Cobre de Chile, March 29, 12 p. (Accessed July 31, 2018, at https://www.codelco.com/prontus_codelco/site/artic/20160404/asocfile/20160404163300/2017_yearendresults_analysis2_1.pdf.)
- Cronimet Mining AG, [undated], Armenia: Karlsruhe, Germany, Cronimet Mining AG, 1 p. (Accessed July 6, 2018, at <http://www.cronimet-mining.am/en/cronimet-mining-in-armenia/zcmc/>.)

CRU Group, 2017, Prices fluctuate amidst supply concerns: CRU Group, July 14. (Accessed July 10, 2018, via <https://www.crugroup.com/>.)

Freeport-McMoRan Inc., 2018, Form 10-K—2017: U.S. Securities and Exchange Commission, 200 p.

International Molybdenum Association, 2018, Global molybdenum use and production up in 2017: London, United Kingdom, International Molybdenum Association press release, April 23. (Accessed July 5, 2018, at <https://www.imoa.info/molybdenum-media-centre/latest-news/latest-news-details.php?objectID=500&lang=en>.)

KGHM International Ltd., [undated], Robinson: Ruth, NV, KGHM International Ltd. (Accessed September 17, 2018, at <https://kgmh.com/en/our-business/mining-and-enrichment/robinson>.)

KGHM Polska Miedz S.A., 2018, Results of the group for the 4th quarter and full-year 2017: Lubin, Poland, KGHM Polska Miedz S.A., March 16, 41 p. (Accessed July 31, 2018, via <https://kgmh.com/en/investors/results-centre/archive>.)

Langeloth Metallurgical Co., LLC, [undated], Langeloth Metallurgical Company: Langeloth, PA, Langeloth Metallurgical Co., LLC. (Accessed June 28, 2018, via <https://www.langeloth.com/>.)

Rio Tinto plc, 2018, Annual report 2017: London, United Kingdom, Rio Tinto plc, February 28, 262 p.

Roskill Information Services Ltd., 2017, Global industry markets and outlook to 2026: London, United Kingdom, Roskill Information Services Ltd., 272 p.

Southern Copper Corp., 2018, Form 10-K—2018: U.S. Securities and Exchange Commission, 184 p.

Taseko Mines Ltd., 2018, Taseko reports 2017 fourth quarter and annual financial results: Vancouver, British Columbia, Canada, Taseko Mines Ltd., February 21, 89 p. (Accessed July 13, 2018, at <https://www.tasekomines.com/assets/docs/q4-2017-20180221142053.pdf>.)

Teck Resources Ltd., 2018, 2017 annual report: Vancouver, British Columbia, Canada, Teck Resources Ltd., February 14, 130 p.

Wheaton Precious Metals Corp., 2018, Annual information form for the year ended December 31, 2017: Vancouver, British Columbia, Canada, Wheaton Precious Metals Corp., 107 p. (Accessed September 7, 2018, at https://s21.q4cdn.com/266470217/files/doc_downloads/annual_information/AIF-for-the-year-ended-December-31-2017-v17-FINAL.PDF.)

GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.

Molybdenum. Ch. in Mineral Commodity Summaries, annual.

Molybdenum. Ch. in United States Mineral Resources, Professional Paper 820, 1973.

Molybdenum. Mineral Industry Surveys, monthly.

Molybdenum (Mo). Ch. in Metal Prices in the United States Through 2010, Scientific Investigations Report 2012–5188, 2013.

Other

Chemical & Engineering News.

Roskill Information Services Ltd.

Engineering and Mining Journal.

Metal Bulletin.

Metal Bulletin, monthly.

Molybdenum. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.

TABLE 1
SALIENT MOLYBDENUM STATISTICS¹

(Metric tons of contained molybdenum)

	2013	2014	2015	2016	2017
United States:					
Concentrate:					
Production	61,000	68,200	47,400	36,200	40,700
Shipments	68,100	71,900	50,500	38,600	40,400
Reported consumption ²	W	W	W	W	W
Imports for consumption	13,100	15,800	12,900	14,900	24,300
Exports	48,600	60,500	36,800	27,700	39,800
Stocks, December 31:					
Concentrate, mine and plant	W	W	W	W	W
Product producers ³	W	W	W	W	W
Consumers	1,820	2,010	1,880	1,910 ^r	2,010
Total	1,820	2,010	1,880	1,910 ^r	2,010
Primary products:					
Production	W	W	W	W	W
Shipments	W	W	W	W	W
Reported consumption	18,600	19,500	17,600	15,800 ^r	17,300
Imports for consumption	7,190	9,500	4,540	7,940 ^r	11,700
World, mine production	281,000	305,000 ^r	288,000	278,000	297,000

^rRevised. W Withheld to avoid disclosing company proprietary data.

¹Table includes data available through September 26, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Molybdenum concentrates roasted to make molybdic oxide.

³Includes 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 2017

State and mine	County	Operator	Source of molybdenum
Arizona:			
Bagdad	Yavapai	Freeport-McMoRan Inc.	Copper-molybdenum ore, concentrated.
Morenci	Greenlee	do.	Do.
Pinto Valley	Gila	Capstone Mining Corp.	Do.
Sierrita	Pima	Freeport-McMoRan Inc.	Do.
Colorado:			
Climax	Lake	do.	Molybdenum ore, concentrated.
Henderson	Clear Creek	do.	Do.
Montana, Continental Pit	Silver Bow	Montana Resources LLP	Copper-molybdenum ore, concentrated.
Nevada, Robinson	White Pine	Robinson Nevada Mining Co. ¹	Do.
Utah, Bingham Canyon	Salt Lake	Rio Tinto Kennecott	Do.

Do., do. Ditto.

¹Wholly owned subsidiary of KGHM International Ltd.

TABLE 3
U.S. REPORTED CONSUMPTION, BY END USES, AND CONSUMER STOCKS OF MOLYBDENUM MATERIALS¹

(Kilograms of contained molybdenum)

End use	Molybdic oxides	Ferromolybdenum ²	Ammonium and sodium molybdate	Molybdenum scrap	Other	Total
2016:						
Steel:						
Carbon	W	W	--	--	--	W
High-strength low-alloy	W	103,000	--	--	--	103,000
Stainless and heat-resisting	2,190,000	674,000	--	(3)	W	2,870,000
Full alloy	3,260,000	1,890,000	--	--	W	5,150,000
Tool	W	W	--	(3)	--	W
Total	5,450,000	2,670,000	--	(3)	W	8,110,000
Cast irons (gray, malleable, ductile iron)	W	329,000	--	--	W	329,000
Superalloys	201,000	W	--	(3)	572,000 ^r	773,000 ^r
Alloys (other than steels, cast irons, superalloys):						
Welding materials (structural and hard-facing)	--	W	--	--	W	W
Other alloys	2,650	90,000	--	--	W	92,700
Mill products made from metal powder ⁴	--	--	--	--	W	W
Cemented carbides and related products ⁵	--	--	--	--	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	1,910,000 ^r	328,000	5,110	(3)	4,050,000 ^r	6,290,000 ^r
Grand total	7,560,000 ^r	3,410,000	5,110	(3)	4,780,000 ^r	15,800,000 ^r
Stocks, December 31	638,000 ^r	360,000	7,080	(6)	(6)	1,910,000 ^r
2017:						
Steel:						
Carbon	W	W	--	--	--	W
High-strength low-alloy	W	170,000	--	--	--	170,000
Stainless and heat-resisting	2,410,000	673,000	--	(3)	109,000	3,190,000
Full alloy	3,240,000	1,890,000	--	--	W	5,120,000
Tool	W	W	--	(3)	--	W
Total	5,640,000	2,730,000	--	(3)	109,000	8,480,000
Cast irons (gray, malleable, ductile iron)	W	316,000	--	--	W	316,000
Superalloys	W	W	--	(3)	1,090,000	1,090,000
Alloys (other than steels, cast irons, superalloys):						
Welding materials (structural and hard-facing)	--	W	--	--	W	W
Other alloys	2,290	46,000	--	--	W	48,300
Mill products made from metal powder ⁴	--	--	--	--	W	W
Cemented carbides and related products ⁵	--	--	--	--	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	2,540,000	492,000	5,110	(3)	4,200,000	7,240,000
Grand total	8,180,000	3,580,000	5,110	(3)	5,550,000	17,300,000
Stocks, December 31	676,000	398,000	6,700	(6)	(6)	2,010,000

^rRevised. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified uses: Other." -- Zero.

¹Table includes data available through September 26, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes calcium molybdate.

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

⁴Includes ingot, wire, rod, and sheet.

⁵Includes construction, mining, oil and gas, and metal working machinery.

⁶Withheld to avoid disclosing company proprietary data; included in "Total."

TABLE 4
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY OR LOCALITY¹

(Metric tons, gross weight, and thousand dollars)

Product and country or locality	HTS ² code	2016		2017	
		Quantity	Value	Quantity	Value
Oxides and hydroxides: ³	2825.70.0000				
Argentina		--	--	3	51
Brazil		48	677	79	1,290
Canada		104	1,090	74	1,090
Germany		7	147	19	328
Japan		67	1,250	72	1,340
Korea, Republic of		17	332	23	471
Mexico		80	783	75	870
Netherlands		326	4,450	90	1,440
Turkey		180	2,310 ^r	60	904
Other [11 countries and (or) localities]		25 ^r	548 ^r	35	637
Total		853	11,600	533	8,420
Molybdates, all (contained weight): ⁴	2841.70.0000				
Canada		254	3,000	281	4,350
China		115	1,720	169	2,530
Germany		20 ^r	171 ^r	205	3,140
Mexico		538	7,030	369	6,420
Netherlands		311	2,400	311	2,730
Other [32 countries and (or) localities]		202 ^r	2,870 ^r	194	2,840
Total		1,440	17,200	1,530	22,000
Ferromolybdenum: ^{4,5}	7202.70.0000				
Argentina		(6)	4	--	--
Australia		--	--	1	36
Canada		578 ^r	12,100 ^r	586	10,100
Colombia		2	41	(6)	4
Denmark		1	37	1	37
Mexico		60	1,060	39	593
Total		641 ^r	13,300	628	10,800
Molybdenum, other: ^{3,7}	Various ⁸				
Brazil		16	615	24	1,060
Canada		60 ^r	2,870 ^r	58	2,470
China		100 ^r	6,380 ^r	42	3,210
Germany		136 ^r	9,220 ^r	225	12,500
India		27	1,260	23	1,330
Israel		38	3,030	37	2,850
Japan		35 ^r	2,250 ^r	45	3,420
Korea, Republic of		129	12,800	143	11,800
Taiwan		84	5,100	101	5,160
United Kingdom		85 ^r	7,030 ^r	83	6,160
Other [44 countries and (or) localities]		121 ^r	9,150 ^r	104	9,600
Total		832 ^r	59,700 ^r	886	59,600

¹Revised. -- Zero.

²Table includes data available through September 26, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

³Harmonized Tariff Schedule of the United States (HTS).

⁴Presentation of annual data is based on the quantities (gross weight) of the 10 leading countries and (or) localities in 2017.

⁵Presentation of annual data is based on the quantities (gross weight) of the 5 leading countries and (or) localities in 2017.

⁶Ferromolybdenum contains about 60% to 65% molybdenum.

⁷Less than ½ unit.

⁸Includes powder, unwrought, waste and scrap, wire, wrought, and other.

⁹Includes 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 UNROASTED CONCENTRATES), BY COUNTRY OR LOCALITY^{1,2}

(Metric tons, contained weight, and thousand dollars)

Country or locality	2016		2017	
	Quantity	Value	Quantity	Value
Belgium	1,820	23,500	5,350	66,500
Canada	1,290	16,900	1,570	19,800
Chile	--	--	1,550	22,700
China	3,500	44,400	4,950	75,000
Japan	2,100	28,800	2,860	47,700
Korea, Republic of	152	1,690	876	13,700
Mexico	118	1,660	704	8,910
Netherlands	15,400	184,000	14,000	206,000
United Kingdom	2,720	35,100	7,220	120,000
Vietnam	168	1,760	393	5,340
Other [10 countries and (or) localities]	410 ^r	5,540 ^r	347	5,320
Total	27,700	343,000	39,800	592,000

^rRevised. -- Zero.

¹Table includes data available through September 26, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Presentation of annual data is based on the quantities (contained weight) of the 10 leading countries and (or) localities in 2017.

Source: U.S. Census Bureau.

TABLE 6
U.S. EXPORTS OF MOLYBDENUM PRODUCTS¹

Item	HTS ² code	2016			2017		
		Quantity (metric tons)		Value	Quantity (metric tons)		Value
		Gross weight	Contained weight	(thousands)	Gross weight	Contained weight	(thousands)
Molybdenum ore and concentrates:							
Roasted	2613.10.0000	NA	11,800	\$158,000	NA	17,600	\$287,000
Unroasted	2613.90.0000	NA	15,900	185,000	NA	22,300	305,000
Molybdenum chemicals:							
Oxides and hydroxides	2825.70.0000	853	NA	11,600	533	NA	8,420
Molybdates, all	2841.70.0000	NA ^r	1,440 ^r	17,200	1,530	NA	22,000
Ferromolybdenum	7202.70.0000	641 ^r	449 ^r	13,300	628	440	10,800
Molybdenum powders	8102.10.0000	143	NA	5,660	130	NA	5,820
Molybdenum unwrought, bars and rods	8102.94.0000	68	NA	2,520	30	NA	1,120
Molybdenum waste and scrap	8102.97.0000	200	NA	2,960	152	NA	2,430
Molybdenum wire	8102.96.0000	27	NA	2,980	17	NA	1,860
Molybdenum, other	Various ³	594 ^r	NA	48,600	709	NA	50,800
Total		XX	XX	448,000	XX	XX	695,000

^rRevised. NA Not available. XX Not applicable.

¹Table includes data available through September 26, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States (HTS).

³Includes 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 OR LOCALITY¹

(Metric tons, gross weight, and thousand dollars)

Product and country or locality	HTS ² code	2016		2017	
		Quantity	Value	Quantity	Value
Oxides and hydroxides:	2825.70.0000				
Chile		2,130	27,400	1,610	24,300
China		726	9,630	693	10,400
Germany		5	97	19	290
Japan		--	--	55	812
Korea, Republic of		404	4,030	544	6,930
Singapore		19	279	--	--
Total		3,280	41,400	2,920	42,700
Molybdates, all: ³	Various ⁴				
Chile		1,200	13,400	1,350	17,800
China		1,440	17,000	1,150	14,300
India		121	1,020	202	1,960
Netherlands		10	154	18	247
Poland		68	513	87	739
Other [9 countries and (or) localities]		26 ^r	524 ^r	31	664
Total		2,870	32,700	2,840	35,700
Molybdenum orange:	3206.20.0020				
Canada		534	1,830	264	1,650
China		4	27	6	46
Colombia		103	388	115	481
India		95	172	455	1,200
Mexico		2	9	--	--
Total		737	2,420	840	3,370
Ferromolybdenum: ^{3, 5}	7202.70.0000				
Canada		434	6,990	417	6,860
Chile		1,700	28,600	3,070	45,500
China		67	1,250	376	6,170
Korea, Republic of		505	9,090	3,610	51,800
United Kingdom		37	697	51	641
Other [6 countries and (or) localities]		7	209	66	1,160
Total		2,750	46,900	7,590	112,000
Other: ⁶	Various ⁷				
Austria		414	13,400	548	17,600
Canada		264	4,440	474	8,770
China		909	20,400	977	24,300
Egypt		--	--	15	54
Germany		201	7,160	397	12,500
Japan		37	1,640	56	1,740
Korea, Republic of		18	240	39	797
Pakistan		--	--	48	785
Russia		4	300	35	884
United Kingdom		62	1,320	140	2,840
Other [22 countries and (or) localities]		41 ^r	1,890 ^r	34	2,530
Total		1,950	50,800	2,770	72,700

^rRevised. -- Zero.

¹Table includes data available through September 26, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States (HTS).

³Presentation of annual data is based on the quantities (gross weight) of the five leading countries and (or) localities in 2017.

⁴Includes HTS codes 2841.70.1000 and 2841.70.5000.

⁵Ferromolybdenum contains about 60% to 65% molybdenum.

⁶Presentation of annual data is based on the quantities (gross weight) of the 10 leading countries and (or) localities in 2017.

⁷Includes 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 UNROASTED CONCENTRATES), BY COUNTRY OR LOCALITY¹

(Metric tons, contained weight, and thousand dollars)

Country or locality	2016		2017	
	Quantity	Value	Quantity	Value
Armenia	--	--	79	1,200
Canada	996 ^r	15,600 ^r	2,190	39,400
Chile	6,290 ^r	80,700 ^r	6,440	112,000
China	119 ^r	1,190	179	3,090
Japan	--	--	(2)	27
Mexico	513 ^r	10,100	1,880	31,600
Mongolia	--	--	130	1,890
Peru	6,990 ^r	106,000	13,400	224,000
Taiwan	--	--	1	9
Total	14,900 ^r	214,000 ^r	24,300	414,000

-- Zero.

¹Table includes data available through September 26, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 9
U.S. IMPORTS FOR CONSUMPTION OF MOLYBDENUM PRODUCTS¹

Item	HTS ² code	2016			2017		
		Quantity (metric tons)		Value	Quantity (metric tons)		Value
		Gross weight	Contained weight	(thousands)	Gross weight	Contained weight	(thousands)
Molybdenum ore and concentrates:							
Roasted	2613.10.0000	6,750	4,010	\$59,300	11,100	6,630	\$116,000
Unroasted	2613.90.0000	21,800	10,900	154,000 ^r	36,000	17,600	297,000
Molybdenum chemicals:							
Oxides and hydroxides	2825.70.0000	3,280	NA	41,400	2,920	NA	42,700
Molybdates, all	Various ³	2,870	1,580	32,700	2,840	1,550	35,700
Molybdenum orange	3206.20.0020	737	NA	2,420	840	NA	3,370
Ferromolybdenum	7202.70.0000	2,750	1,900	46,900	7,590	5,130	112,000
Molybdenum powders	8102.10.0000	160	151	4,630	368	350	10,400
Molybdenum unwrought, bars and rods	8102.94.0000	882	879	16,000	987	985	20,700
Molybdenum waste and scrap	8102.97.0000	669	636	12,200	1,150	1,120	23,700
Molybdenum wire	8102.96.0000	18	NA	2,280	26	NA	2,600
Molybdenum, other	Various ⁴	218 ^r	NA	15,600	233	NA	15,300
Total		40,100	XX	388,000 ^r	64,000	XX	680,000

¹Revised. NA Not available. XX Not applicable.

¹Table includes data available through September 26, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

²Harmonized Tariff Schedule of the United States (HTS).

³Includes HTS codes 2841.70.1000 and 2841.70.5000.

⁴Includes 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 OR LOCALITY¹

(Metric tons of contained molybdenum)

Country or locality ²	2013	2014	2015	2016	2017
Argentina	1,802 ^r	908	811	450 ^r	450 ^e
Armenia	6,900	7,162	6,300	5,771 ^r	5,800 ^e
Canada	7,956	9,358	2,505	2,783 ^r	5,286
Chile	38,715	48,770	52,579	55,834 ^r	62,454
China ^e	122,000	129,000	135,000	129,000	130,000
Iran	3,471	3,494	3,500	3,500 ^e	3,500 ^e
Korea, Republic of	461 ^r	492 ^r	259 ^r	--	--
Mexico	12,562	14,370	12,279	11,896	13,985
Mongolia	1,819	1,999	2,557	2,444	1,800
Peru	18,140	17,018	20,153	25,757	28,141
Russia	4,753	3,114	3,254 ^r	3,100 ^r	3,100 ^e
Turkey	800	900	900 ^e	900 ^e	900 ^e
United States	61,000	68,200	47,400	36,200	40,700
Uzbekistan	490	450	450 ^e	450 ^e	450 ^e
Total	281,000	305,000 ^r	288,000	278,000	297,000

^eEstimated. ^rRevised. -- Zero.

¹Table includes data available through July 23, 2018. All data are reported unless otherwise noted. Totals, U.S. data, and estimated data are rounded to three significant digits; may not add to totals shown.

²In addition to the countries and (or) localities listed, Bulgaria and Kyrgyzstan may have produced molybdenum, but available information was inadequate to make reliable estimates of output.

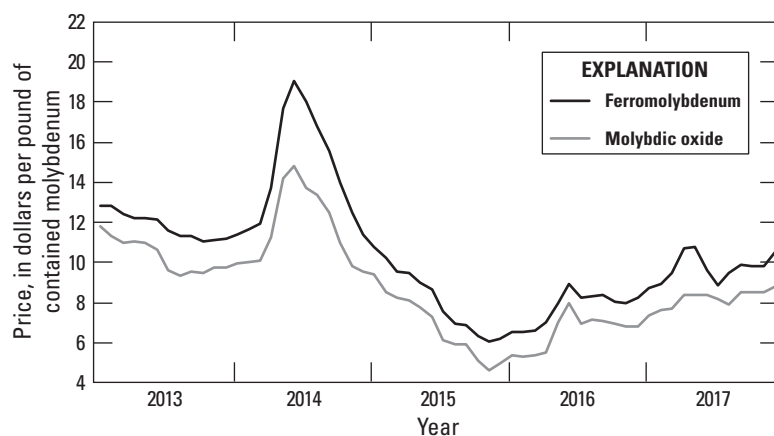


Figure 1. U.S. average monthly prices for ferromolybdenum and molybdc oxide from January 2013 through December 2017. Source: CRU Group.