

MOLYBDENUM

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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 molybdc oxide (MoX) or ferromolybdenum (FeMo), is frequently used in combination with or added to chromium, columbium (niobium), manganese, nickel, 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 are serviceable under high stress, expanded temperature ranges, and highly corrosive environments. Moreover, molybdenum finds significant use as a refractory metal in numerous chemical applications, including catalysts, lubricants, and pigments. The variety of uses for molybdenum materials, few of which afford acceptable substitution, has resulted in a doubling of consumption in the Western World to about 136,000 metric tons per year (t/yr) (300 million pounds per year) in 2000 from about 68,000 t/yr (150 million pounds per year) in 1983 (Adams, 2001).

Distribution of molybdenum reserves and production capacity was concentrated in a few countries of the world. World mine output was estimated to be 125,000 metric tons (t) (molybdenum contained in concentrate), of which, in descending order of production, the United States, China, Chile, Peru, Canada, Mexico, and Armenia provided more than 94% (table 11). Chile, China, and the United States also possessed about 85% of the estimated 19 million metric tons (Mt) of molybdenum in the world reserve base.

Production

Domestic production data for molybdenum were derived by the U.S. Geological Survey by means of three separate voluntary surveys. These surveys are Molybdenum Ore and Concentrate (annual), Molybdenum Concentrate (monthly), and Molybdenum Products and Molybdenum Concentrates (monthly). Surveys are sent to all operations that produce molybdenum ore and products. All eight operations to which surveys were sent responded, representing 100% of the U.S. production listed in table 1.

In 2003, U.S. mine production of molybdenum concentrate was 33,500 t, about a 5% increase from 32,000 t in 2002. World mine production of molybdenum in 2003 increased to 125,000 t, about a 3% increase from 121,000 t in 2002. The U.S. share of world production remained at 27% in 2003. Net production of molybdenum products increased to 11,800 t in 2003 from 10,500 t in 2002 (table 2).

Primary molybdenum production continued at the Henderson Mine in Colorado, the Questa Mine in New Mexico, and the Thompson Creek Mine in Idaho. The Climax Mine in Colorado has been inactive since 1995 and will not be brought back online

until after the nearby Henderson deposit in Empire, CO, about 100 kilometers east, is exhausted. The Tonopah Mine in Nevada was being permanently closed. Molybdenum was produced as a byproduct of copper production at the Bagdad and Sierrita Mines in Arizona and at the Bingham Canyon Mine in Utah. The byproduct molybdenum recovery circuit at the Chino Mine in New Mexico remained on care and maintenance. Montana Resources' Continental Pit in Montana resumed operation in November 2003, with the first shipments of molybdenite concentrate expected in early 2004 (Platts Metals Week, 2003d).

With byproduct molybdenum recovery at a copper mine, all mining costs associated with producing the molybdenum concentrate are allocated to the primary metal (copper). Owing to this cost advantage, byproduct molybdenite recovery from copper circuits at selected porphyry copper mines was estimated to account for 75% of Western and 50% of worldwide molybdenum supply. Phelps Dodge Corp. and Kennecott Utah Copper Corp. restored copper production and byproduct molybdenum recovery in 2003, but Kennecott production of byproduct molybdenum remained reduced owing to unexpectedly low ore grades (Metal-Pages, 2003a§¹).

Primary molybdenum mines, staffed to operate at less than 50% of capacity, operate in a swing capacity and are unable to quickly ramp up production to meet spikes in demand. The Thompson Creek Mine produced at less than 50% of its 9,000-t/yr (20-million-pound-per-year) capacity in 2003, the Henderson Mine also operated at less than 50% of its 18,000-t/yr (40-million-pound-per-year) capacity, and the Questa Mine and its mill were operated separately at intervals of about 6 months (Ryan's Notes, 2003c).

Consumption

In 2003, reported consumption (roasting) of molybdenum concentrate was 27,500 t, an increase of about 6,300 t compared with that of 2002. The increase resulted from increased mine production and because molybdenum concentrates from Thompson Creek were roasted domestically in 2003. Domestic mine production of molybdenum concentrate was roasted, exported for conversion, or purified to lubricant-grade molybdenum disulfide. Technical-grade MoX consumption in 2003 was slightly less than that of 2002. Oxide was the chief form of molybdenum used by industry, particularly in making full alloy, stainless, and tool steel, and superalloys; however, some of the oxide was converted to other molybdenum products, such as ammonium and sodium molybdates, FeMo, high-purity oxide, and metal powder (table 3).

¹References that include a section mark (§) are found in the Internet References Cited section.

Metallurgical applications continued to dominate molybdenum use in 2003, accounting for about 75% of total consumption (table 3). In 2003, ferromolybdenum accounted for 39% of the molybdenum-bearing forms used to make steel, a 3% increase from that of 2002. Nonmetallurgical applications included catalysts, chemicals, lubricants, and pigments. The dominant nonmetallurgical use was in catalysts.

Stocks

In 2003, producer plus consumer industry stocks were about 4,400 t, a decrease of about 1,700 t compared with those of 2002. Inventories of molybdenum in concentrate at mines and plants decreased by about 1,400 t. Producer stocks of molybdenum in such products as FeMo, molybdates, MoX, metal powders, and other types decreased by about 1,500 t compared with those of 2002. Total stocks of about 6,900 t represented about a 23-week supply. Supply was calculated as reported stocks divided by annual consumption (table 1).

Prices

Prices were reported in Platts Metals Week in dollars per kilogram of contained molybdenum. The time-average prices for 2003 were MoX, \$11.653 per kilogram and FeMo, \$13.001 per kilogram of contained molybdenum, which represented increases of 41% and 20%, respectively, compared with 2002 prices. Molybdenum prices rose steadily in 2003 before spiking in December. The MoX monthly average price ranged from \$7.904 per kilogram in January to \$13.035 per kilogram in November, and the FeMo monthly average price ranged from \$10.406 per kilogram in January to \$15.295 per kilogram in November. In December the MoX price spiked at \$15.818 per kilogram, and the FeMo price spiked at \$17.733.

Foreign Trade

In 2003, molybdenum-containing material exports collectively contained about 30,100 t of molybdenum and were valued at \$268 million (table 6). Imports for consumption of molybdenum-containing materials (products) collectively were valued at \$131 million (table 9).

World Industry Structure

Capacity.—As of December 31, U.S. rated capacity for mines and mills was estimated to be 75,000 t/yr of contained metal. Rated capacity was 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 operating plants temporarily closed that, in the judgment of the author, can be brought into production within a short period of time with minimal capital expenditure.

Reserves.—U.S. molybdenum reserve base was estimated to be about 5.4 Mt, about 28% of the world molybdenum reserve base. About 90% of U.S. reserves occur in large low-grade

porphyry molybdenum deposits mined or anticipated to be mined primarily for molybdenum and as an associated metal sulfide in low-grade porphyry copper deposits. These deposits were in Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, and Utah. Other molybdenum sources contribute insignificantly to U.S. reserves.

Most Canadian reserves of molybdenum were associated with porphyry molybdenum and porphyry copper-molybdenum deposits in British Columbia. Other Canadian reserves were associated with minor copper-molybdenum porphyry deposits in New Brunswick and Quebec.

Molybdenum reserves in Central America and South America were associated mainly with large copper porphyry deposits. Of several such deposits in Chile, the Chuquicamata and El Teniente deposits were among the world's largest and accounted for 85% of molybdenum reserves in Chile. Mexico and Peru had substantial reserves. La Caridad deposit in Mexico was a large producer. Numerous other porphyry copper deposits that may contain recoverable quantities of molybdenum have been identified in Central America and South America. Many of these deposits were being actively explored and evaluated and could substantially add to reserves in the future. Reserves of molybdenum in China and the Commonwealth of Independent States were thought to be substantial, but definitive information about the current sources of supply or prospects for future development in these two areas was lacking.

World Review

Armenia.—While Chinese FeMo exports to Europe have decreased, FeMo exports from Armenia to Europe have increased to 1,464 t in 2002 from 156 t in 1997, and FeMo exports from Iran to Europe have increased to 11,289 t in 2002 from 50 t in 1997. Armenia and Iran have shifted to production of downstream products; previously, concentrates produced in those countries were shipped to Russia for processing (Ryan's Notes, 2003a).

Canada.—With the runup in molybdenum prices, the Endako open pit molybdenum mine at Fraser Lake, British Columbia, reportedly returned to profitability. The mine continued to operate 24 hours per day aided by subfreezing weather overnight that helped to stabilize rock on the sides of the pit. Endako is owned by Thompson Creek Mining Ltd. and Nissho Iwai Moly Resources Inc. (Platts Metals Week, 2003a). The mine has almost completely recovered from a 3-Mt rockslide on December 10, 2002, near its in-pit crusher (Platts Metals Week, 2003b). The mine was near closure 2 years ago and was able to stay open only when about one-half of its electricity costs were deferred.

Chile.—Chilean producer Molibdenos y Metales SA (Molymet) completed the purchase of the Sadaci conversion plant in Ghent, Belgium, in February 2003. Prior to this purchase, Molymet's molybdenum oxide roasting capacity totaled roughly 31,000 t/yr (68 million pounds per year) at facilities in Chile and Mexico. Sadaci is believed to have a roasting capacity of about 10,000 t/yr (22 million pounds per year). With this acquisition, Molymet essentially will be the only roasting facility open to traders in the future (Ryan's Notes, 2003e).

Chilean producer Corporacion Nacional del Cobre, Chile (Codelco) shut down the Chuquicamata roaster in early March for unplanned maintenance. At that time, the company anticipated resuming roasting by the end of March; however, Codelco decided to make major technical improvements so that its molybdenum roaster did not resume operation until October (Ryan's Notes, 2003b). Codelco secured roasting capacity for its concentrates and expected to produce 23,000 t (50 million to 51 million pounds) of molybdenum in 2003.

China.—Two separate mining accidents in early May in the Huludao region of China's Liaoning Province caused Chinese authorities to shut all mines in the region for safety inspections (Platts Metals Week, 2003c). Although some mines resumed production by the end of the month, many remained shut, which reduced concentrate supply. Many FeMo plants, which continued to operate in May with reduced feedstocks, were required to shut down for state inspections in June. China accounted for about 25% of the global molybdenum mine output of 125,000 t/yr, with the Huludao region producing at least 30% of the Chinese molybdenum concentrate output. Shipments of Chinese FeMo to Europe decreased since the European Union imposed an antidumping duty on Chinese FeMo in 2002 (Ryan's Notes, 2003a). In March, Chinese exports to Asian countries exceeded exports to Europe for the first time. Of the Asian countries, Japan received the most FeMo, followed by the Republic of Korea and Taiwan.

In June, about 12 mines in the Huludao region resumed molybdenum production after passing safety inspections in the wake of the two incidents in early May. Roughly 120 of the 200 mines in the region were expected to be restarted. The remaining 80 mines are not expected to pass inspection and would be mothballed or declared bankrupt. Production capacity in the Huludao region was expected to decrease by about 20% as a result of the closures (Ryan's Notes, 2003g).

Winter weather caused the closure of many mines, and the failure of a tailings pond in Liaoning Province led the Government to close all ore-dressing plants in December. Since Liaoning Province accounted for 30% of primary molybdenum concentrate production in China, this affected roasters and converters downstream. In addition, Chinese processing plants that relied on concentrate imports from Russia were hit by a force majeure at the Sorsk molybdenum plant in Russia, which normally exported one-half of its 3,000-t/yr (6-million- to 7-million-pound-per-year) annual production to Chinese consumers (Metal Bulletin Research Ferro-alloys Monthly, 2003).

Russia.—Russia retained its 49% share in the Russian-Mongolian copper-and-molybdenum joint-venture Erdenet Mining Corporation. Erdenet has developed several ore deposits, which make up several fields, and is a leading Mongolian producer of raw copper. Reserves in the northwest mining sector are estimated to be 6 Mt of copper and 170,000 t of molybdenum. The company was attempting to raise processing capacity in 2004 and was considering building a 25,000-t/yr copper cathode plant (Metal-Pages, 2003c§).

Outlook

Montana Resources, Inc., which resumed production at its Continental Pit in November, reportedly sold its 2004

molybdenum concentrate output, estimated to be 3,200 t (7 million pounds), to three parties. The buyers are thought to be Thompson Creek Mining Company, 60%; Phelps Dodge, 20%; and Sadaci NV, 20% (Ryan's Notes, 2003d).

Phelps Dodge announced that it expected to achieve full capacity production at its Bagdad concentrator by the end of the second quarter of 2004 and at its Sierrita concentrator by the fourth quarter of 2004. Phelps Dodge expected to produce about 15,000 t (33 million pounds) of molybdenum concentrate in 2004 from the two operations, an increase from 13,600 t (30 million pounds) in 2003. While achieving full capacity production at the two mines depended on the ore grades being mined, the output numbers showed that Phelps Dodge operated at about 80% of its historical high in 2003 and would achieve about 90% of its historical high in 2004 (Ryan's Notes, 2004).

Thompson Creek Metals Company, LLC successfully restarted production at its Langeloth, PA, roaster in December and began processing concentrates from its Thompson Creek Mine. Since February 2002, the concentrates were sent to Phelps Dodge for toll roasting. The company will operate the largest of its four roasters with a capacity of around 5,400 t/yr (12 million pounds per year). The overburden stripping campaign initiated at the Thompson Creek Mine in midyear 2002 was set to finish in March 2004 and will increase mine capacity by 30% (Ryan's Notes, 2003f).

Relative to the remaining U.S. producers, neither the Henderson Mine nor the Questa Mine have announced any expansion plans. Production of molybdenum at Kennecott Utah Copper fell by about 28% year on year to 4,600 t in 2003 owing to reduced ore grade (Metal-Pages, 2003a§).

Supply-side pressures in Chile, China, Russia, and the United States drove molybdenum prices higher in December (Metal Bulletin Research, 2003). The critical factor for the molybdenum market in the immediate future will be the continued recovery of the copper market and the potential increased byproduct molybdenum supply. If the copper market continues to advance, the Western molybdenum concentrate supply tightness will ease, and the primary molybdenum mines can continue to operate as swing producers at or below present levels. If copper price recovery is not maintained, however, the primary mines will need to increase staff and bring additional resources online to offset reduced byproduct molybdenum concentrate availability. The challenge for the primary mines will be to estimate how long the molybdenum prices will stay above a level that justifies capital investment and staff increases.

Growth in the production of stainless steel and superalloys in Asia, Europe, and South Africa was expected to continue. There was potential for growth in the United States as economic conditions improve and the benefits of consolidation in the steel industry take effect. Finally, the growth of the domestic Chinese steel industry will continue to consume additional molybdenum units. China's growing demand for stainless steel will also influence the molybdenum market as major steel producers plan to build steel plants in China to satisfy stainless steel demand (Metal-Pages, 2003b§).

Because of abundant resources and adequate production capacity in Chile, China, the United States, and other countries, world producers expected to readily meet the future requirement

for molybdenum. The principal use for molybdenum will continue to be in chemicals and catalysts and as an additive in steel manufacturing in general, most importantly alloy and stainless steel.

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GENERAL SOURCES OF INFORMATION

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Other

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TABLE 1
SALIENT MOLYBDENUM STATISTICS¹

(Metric tons of contained molybdenum unless otherwise specified)

| | 1999 | 2000 | 2001 | 2002 | 2003 | |
|-----------------------------------|-----------|----------------------|----------------------|----------------------|------------------------|-----------|
| United States: | | | | | | |
| Concentrate: | | | | | | |
| Production | 42,400 | 40,900 | 37,600 | 32,000 ^f | 33,500 | |
| Shipments: | | | | | | |
| Quantity | 42,800 | 40,400 | 37,000 | 32,300 | 33,600 | |
| Value | thousands | \$251,000 | \$210,000 | \$192,000 | \$232,000 ^f | \$324,000 |
| Reported consumption ² | 34,500 | 33,800 | 33,300 | 21,200 ^f | 27,500 | |
| Imports for consumption | 6,390 | 6,120 | 6,010 | 4,710 | 5,190 | |
| Stocks, December 31: | | | | | | |
| Concentrate, mine and plant | 4,580 | 4,030 | 4,210 | 3,870 ^f | 2,520 | |
| Product producers ³ | 5,340 | 5,360 | 5,600 | 4,300 | 2,760 | |
| Consumers | 2,070 | 2,050 | 869 | 1,800 ^f | 1,630 | |
| Total | 12,000 | 11,400 | 10,700 | 9,970 ^f | 6,910 | |
| Primary products: | | | | | | |
| Production | 39,800 | 42,900 | 40,300 | 31,300 | 41,400 | |
| Shipments | 39,000 | 34,600 | 32,600 | 27,500 | 30,100 | |
| Reported consumption | 18,700 | 18,300 | 15,800 | 15,300 ^f | 15,700 | |
| World, mine production | 129,000 | 134,000 ^f | 133,000 ^f | 121,000 ^f | 125,000 ^e | |

^eEstimated. ^fRevised.

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

²Molybdenum concentrates roasted to make molybdenum oxide.

³Includes technical and purified molybdc oxide, briquets, ferromolybdenum, phosphomolybdc disulfide, molybdc acid, ammonium, molybdate, sodium molybdate, calcium molybdate, molybdenum metal, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.

TABLE 2
PRODUCTION, SHIPMENTS, AND STOCKS OF MOLYBDENUM PRODUCTS IN THE UNITED STATES¹

(Metric tons of contained molybdenum)

| | Metal powder | | Other ² | | Total | |
|---|--------------|-------|--------------------|--------|--------|--------|
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Received from other producers | -- | -- | 15,500 | 16,800 | 15,500 | 16,800 |
| Gross production during year | 2,700 | 3,490 | 28,600 | 37,900 | 31,300 | 41,400 |
| Molybdenum products used to make other products | 2,190 | 2,730 | 18,600 | 26,900 | 20,700 | 29,600 |
| Net production | 513 | 760 | 10,000 | 11,000 | 10,500 | 11,800 |
| Shipments | 601 | 739 | 26,900 | 29,300 | 27,500 | 30,100 |
| Producer stocks, December 31 | 172 | 194 | 4,130 | 2,570 | 4,300 | 2,760 |

-- Zero.

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

²Includes ferromolybdenum, molybdic oxides, phosphomolybdic acid, molybdenum disulfide, molybdic acid, ammonium molybdate, calcium molybdate, sodium molybdate, molybdenum metal, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.

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 |
|--|------------------------|------------------------------|-------------------------------|---------------------|------------------------|-------------------------|
| 2002: | | | | | | |
| Steel: | | | | | | |
| Carbon | 240,000 ^r | 390,000 ^r | -- | -- | W | 630,000 ^r |
| High-strength low-alloy | 353,000 | 119,000 | -- | -- | W | 472,000 |
| Stainless and heat-resisting | 2,510,000 ^r | 608,000 ^r | -- | 11,600 ^r | 152,000 ^r | 3,280,000 ^r |
| Full alloy | 1,280,000 ^r | 1,840,000 ^r | -- | -- | 19,400 ^r | 3,140,000 ^r |
| Tool | 624,000 ^r | W | -- | 314 ^r | -- ^r | 624,000 ^r |
| Total | 5,010,000 ^r | 2,960,000 ^r | -- | 11,900 ^r | 172,000 ^r | 8,150,000 ^r |
| Cast irons (gray, malleable, ductile iron) | W | 367,000 ^r | -- | -- | 27,100 | 394,000 ^r |
| Superalloys | 669,000 ^r | 23,000 ^r | -- | (3) | 1,110,000 ^r | 1,800,000 ^r |
| Alloys (other than steels, cast irons, superalloys): | | | | | | |
| Welding materials (structural and hard-facing) | -- | 38,700 ^r | -- | -- | 339 | 39,000 ^r |
| Other alloys | W | 53,600 | -- | 816 ^r | 7,020 ^r | 61,500 ^r |
| Mill products made from metal powder ⁴ | -- | -- | -- | -- | 1,040,000 | 1,040,000 |
| Cemented carbides and related products ⁵ | -- | -- | -- | -- | 150 | 150 |
| Chemical and ceramic uses: | | | | | | |
| Pigments | W | -- | 235,000 | -- | -- | 235,000 |
| Catalysts | 1,730,000 ^r | -- | W | -- | 179,000 | 1,910,000 ^r |
| Other | -- | -- | -- | -- | 14,400 | 14,400 |
| Miscellaneous and unspecified uses: | | | | | | |
| Lubricants | -- | -- | -- | -- | 269,000 | 269,000 |
| Other | 201,000 ^r | 115,000 ^r | 892,000 | -- | 152,000 ^r | 1,360,000 ^r |
| Grand total | 7,610,000 ^r | 3,560,000 ^r | 1,130,000 | 12,800 ^r | 2,970,000 ^r | 15,300,000 ^r |
| Stocks, December 31 | 481,000 ^r | 423,000 ^r | 18,200 | 14,200 | 862,000 ^r | 1,800,000 ^r |
| 2003: | | | | | | |
| Steel: | | | | | | |
| Carbon | 239,000 | 350,000 | -- | -- | W | 589,000 |
| High-strength low-alloy | 365,000 | 124,000 | -- | -- | W | 489,000 |
| Stainless and heat-resisting | 2,430,000 | 830,000 | -- | 11,800 | 160,000 | 3,430,000 |
| Full alloy | 1,330,000 | 1,920,000 | -- | -- | 18,500 | 3,270,000 |
| Tool | 577,000 | W | -- | 546 | -- | 577,000 |
| Total | 4,950,000 | 3,230,000 | -- | 12,400 | 178,000 | 8,360,000 |
| Cast irons (gray, malleable, ductile iron) | W | 321,000 | -- | -- | 27,000 | 347,000 |
| Superalloys | 676,000 | 19,500 | -- | (3) | 1,250,000 | 1,950,000 |
| Alloys (other than steels, cast irons, superalloys): | | | | | | |
| Welding materials (structural and hard-facing) | -- | 43,600 | -- | -- | 424 | 44,000 |
| Other alloys | W | 34,600 | -- | 882 | 1,140 | 36,700 |

See footnotes at end of table.

TABLE 3--Continued
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 |
|---|-----------------|------------------------------|-------------------------------|------------------|-----------|------------|
| 2003--Continued: | | | | | | |
| Mill products made from metal powder ⁴ | -- | -- | -- | -- | 1,090,000 | 1,090,000 |
| Cemented carbides and related products ⁵ | -- | -- | -- | -- | 79 | 79 |
| Chemical and ceramic uses: | | | | | | |
| Pigments | W | -- | 235,000 | -- | -- | 235,000 |
| Catalysts | 1,730,000 | -- | W | -- | 179,000 | 1,910,000 |
| Other | -- | -- | -- | -- | 14,400 | 14,400 |
| Miscellaneous and unspecified uses: | | | | | | |
| Lubricants | -- | -- | -- | -- | 289,000 | 289,000 |
| Other | 214,000 | 99,200 | 888,000 | -- | 206,000 | 1,410,000 |
| Grand total | 7,570,000 | 3,750,000 | 1,120,000 | 13,200 | 3,240,000 | 15,700,000 |
| Stocks, December 31 | 460,000 | 206,000 | 41,100 | 51,300 | 866,000 | 1,620,000 |

¹Revised. W Withheld to avoid disclosing company proprietary data; included with "Other" of the "Miscellaneous and unspecified uses" category. -- Zero.

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

²Includes calcium molybdate.

³Included with "Superalloys, other alloys."

⁴Includes construction, mining, oil and gas, and metal working machinery.

⁵Includes ingot, wire, rod, and sheet.

TABLE 4
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY¹

| Product and country | HTS code ² | 2002 | | 2003 | |
|--|-----------------------|------------------------|-------------------|------------------------|-------------------|
| | | Quantity (metric tons) | Value (thousands) | Quantity (metric tons) | Value (thousands) |
| Oxides and hydroxides, gross weight: | | | | | |
| | 2825.70.0000 | | | | |
| Belgium | | 17 | \$119 | -- | -- |
| Brazil | | 4 | 68 ^r | 3 | \$46 |
| Canada | | 1,300 | 8,490 | 1,560 | 13,300 |
| Japan | | 123 | 1,160 | 123 | 1,360 |
| Mexico | | 96 | 757 | 59 | 383 |
| Other | | 123 | 1,180 | 837 | 4,840 |
| Total | | 1,670 | 11,800 | 2,580 | 20,000 |
| Molybdates all, gross weight: ³ | | | | | |
| | 2841.70.0000 | | | | |
| Australia | | 14 | 84 ^r | 10 | 110 |
| Brazil | | 33 | 199 ^r | (4) | 4 |
| Canada | | 320 | 1,340 | 574 | 3,060 |
| Colombia | | 2 ^r | 16 ^r | 10 | 91 |
| Honduras | | 4 ^r | 21 ^r | 2 | 12 |
| Japan | | 226 | 1,670 | 332 | 3,360 |
| Korea, Republic of | | 2 | 18 ^r | 36 | 346 |
| Mexico | | 200 | 2,480 | 262 | 3,390 |
| Netherlands | | 468 | 2,310 | 1,000 | 5,870 |
| Switzerland | | 48 ^r | 478 | -- | -- |
| Taiwan | | 22 ^r | 148 | 25 | 177 |
| Other | | 7 ^r | 146 ^r | 20 | 261 |
| Total | | 1,350 | 8,910 | 2,270 | 16,700 |
| Ferromolybdenum, contained weight: ⁵ | | | | | |
| | 7202.70.0000 | | | | |
| Canada | | 597 | 6,110 | 547 | 7,690 |
| Mexico | | 51 | 483 | 43 | 688 |
| Netherlands | | -- | -- | 26 | 255 |
| Other | | 27 ^r | 374 ^r | 1 | 21 |
| Total | | 676 | 6,970 | 617 | 8,660 |

See footnotes at end of table.

TABLE 4--Continued
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY¹

| Product and country | HTS code ² | 2002 | | 2003 | |
|--|-----------------------|---------------------------|----------------------|---------------------------|----------------------|
| | | Quantity (metric tons) | Value (thousands) | Quantity (metric tons) | Value (thousands) |
| Molybdenum other, gross weight: ⁶ | Various ⁷ | | | | |
| Australia | | 9 ^r | \$234 | 10 | \$150 |
| Brazil | | 50 ^r | 1,250 ^r | 59 | 1,730 |
| Canada | | 62 ^r | 1,830 ^r | 69 | 2,030 |
| France | | 25 ^r | 847 ^r | 25 | 1,060 |
| Germany | | 163 ^r | 2,870 ^r | 66 | 1,510 |
| Hungary | | 5 ^r | 361 ^r | 5 | 158 |
| India | | 18 | 776 ^r | 29 | 752 |
| Italy | | 2 ^r | 48 | 8 | 322 |
| Japan | | 61 ^r | 2,560 ^r | 238 | 6,990 |
| Mexico | | 12 ^r | 1,130 ^r | 14 | 1,000 |
| Netherlands | | 42 | 2,530 ^r | 42 | 1,550 |
| Spain | | 11 ^r | 344 | 7 | 184 |
| Sweden | | 8 | 301 | 2 | 141 |
| Taiwan | | 71 ^r | 1,470 ^r | 117 | 2,200 |
| United Kingdom | | 177 ^r | 4,460 ^r | 279 | 4,230 |
| Other | | 139 ^r | 3,410 ^r | 87 | 4,460 |
| Total | | 855 ^r | 24,400 ^r | 1,060 | 28,500 |

^rRevised. -- Zero.

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

²Harmonized Tariff Schedule of the United States.

³Data erroneously reported as "contained weight" in previous publication.

⁴Less than 1/2 unit.

⁵Ferromolybdenum contains about 60% to 65% molybdenum.

⁶Includes powder, unwrought, waste and scrap, wire, wrought, and other.

⁷Includes HTS codes 8102.10.0000, 8102.94.0000, 8102.97.0000, 8102.96.0000, 8102.95.0000, 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 COUNTRY¹

| Country | 2002 | | 2003 | |
|--------------------|---|----------------------|---|----------------------|
| | Quantity (metric tons of contained molybdenum) | Value (thousands) | Quantity (metric tons of contained molybdenum) | Value (thousands) |
| Australia | 47 ^r | \$446 | 102 | \$1,200 |
| Belgium | 4,382 | 25,646 | 3,192 | 30,226 |
| Brazil | 33 | 310 | 43 | 484 |
| Canada | 1,080 | 5,366 | 910 | 5,084 |
| Chile | 16 ^r | 190 | 368 | 4,467 |
| China | 57 | 223 | 83 | 254 |
| Costa Rica | 13 | 28 | 23 | 46 |
| India | 142 ^r | 1,042 | 44 | 278 |
| Italy | 48 ^r | 291 | 20 | 191 |
| Japan | 1,133 | 10,423 | 2,002 | 21,240 |
| Korea, Republic of | 71 | 460 | 61 | 675 |
| Mexico | 484 | 1,824 | 3,734 | 17,293 |
| Netherlands | 7,328 | 44,096 | 10,861 | 60,865 |
| Sweden | 35 | 242 | 26 | 228 |
| Taiwan | 13 | 131 | 10 | 135 |
| United Kingdom | 4,331 | 20,129 | 7,878 | 49,509 |
| Other | 245 ^r | 1,560 ^r | 137 | 1,851 |
| Total | 19,500 | 112,000 | 29,500 | 194,000 |

^rRevised.

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

Source: U.S. Census Bureau.

TABLE 6
U.S. EXPORTS OF MOLYBDENUM PRODUCTS¹

| Item | HTS code ² | 2002 | | | 2003 | | |
|--|-----------------------|----------------------------|------------------------------------|----------------------|----------------------------|------------------------------------|-------------------|
| | | Gross weight (metric tons) | Contained molybdenum (metric tons) | Value (thousands) | Gross weight (metric tons) | Contained molybdenum (metric tons) | Value (thousands) |
| Molybdenum ore and concentrates, roasted | 2613.10.0000 | NA | 9,290 | \$50,300 | NA | 18,100 | \$116,000 |
| Molybdenum ore and concentrates, other | 2613.90.0000 | NA | 10,200 | 62,100 | NA | 11,400 | 78,500 |
| Molybdenum chemicals: | | | | | | | |
| Oxides and hydroxides | 2825.70.0000 | 1,670 | NA | 11,800 | 2,580 | NA | 20,000 |
| Molybdates, all | 2841.70.0000 | 1,350 ^r | NA | 8,910 | 2,270 | NA | 16,700 |
| Ferromolybdenum | 7202.70.0000 | 1,130 | 676 | 6,970 | 1,030 | 617 | 8,660 |
| Molybdenum powders | 8102.10.0000 | 122 | NA | 3,040 | 308 | NA | 6,770 |
| Molybdenum unwrought, bar and rods | 8102.94.0000 | 138 ^r | NA | 2,790 ^r | 94 | NA | 2,160 |
| Molybdenum waste and scrap | 8102.97.0000 | 266 | NA | 2,750 | 294 | NA | 2,370 |
| Molybdenum wire | 8102.96.0000 | 119 | NA | 4,730 | 111 | NA | 4,730 |
| Molybdenum, other | Various ³ | 209 ^r | NA | 11,100 ^r | 252 | NA | 12,400 |
| Total | | 4,990 ^r | 20,100 ^r | 164,000 ^r | 6,940 | 30,100 | 268,000 |

^rRevised. NA Not available.

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

²Harmonized Tariff Schedule of the United States.

³Includes HTS codes 8102.95.0000 and 8102.99.0000.

Source: U.S. Census Bureau.

TABLE 7
U.S. IMPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY¹

| Product and country | HTS code ² | 2002 | | 2003 | |
|---|-----------------------|------------------------|-------------------|------------------------|-------------------|
| | | Quantity (metric tons) | Value (thousands) | Quantity (metric tons) | Value (thousands) |
| Oxides and hydroxides, gross weight: | | | | | |
| | 2825.70.0000 | | | | |
| Belgium | | 121 | \$691 | 9 | \$66 |
| Chile | | 380 | 2,960 | 279 | 2,570 |
| China | | 444 | 2,320 | 664 | 4,600 |
| Kyrgyzstan | | 177 | 757 | 151 | 775 |
| Russia | | 14 | 121 | -- | -- |
| Other | | 69 | 650 ^r | 196 | 1,600 |
| Total | | 1,210 | 7,500 | 1,300 | 9,600 |
| Molybdates all, contained weight: | | | | | |
| | Various ³ | | | | |
| Belgium | | 4 | 87 | 6 | 188 |
| Canada | | 5 | 74 | 12 | 93 |
| Chile | | 445 | 5,260 | 575 | 7,630 |
| China | | 604 | 6,390 | 468 | 4,440 |
| Germany | | 8 | 107 | 7 | 95 |
| Switzerland | | 20 | 448 | -- | -- |
| Other | | 8 | 89 | 13 | 167 |
| Total | | 1,100 ^r | 12,500 | 1,080 | 12,600 |
| Molybdenum orange, gross weight: | | | | | |
| | 3206.20.0020 | | | | |
| Canada | | 1,150 | 4,980 | 871 | 4,030 |
| Colombia | | 58 | 139 | 46 | 121 |
| Korea, Republic of | | 1 | 3 | 1 | 4 |
| Mexico | | 26 | 58 | 22 | 50 |
| Philippines | | 6 | 31 | 1 | 4 |
| United Kingdom | | 38 | 37 | 20 | 13 |
| Other | | 25 ^r | 78 ^r | 25 | 87 |
| Total | | 1,300 | 5,330 | 987 | 4,310 |
| Ferromolybdenum, contained weight: ⁴ | | | | | |
| | 7202.70.0000 | | | | |
| Belgium | | 4 | 45 | 62 | 509 |
| Canada | | 19 | 260 | 14 | 185 |
| Chile | | 51 | 343 | 13 | 153 |
| China | | 3,250 | 28,200 | 3,400 | 35,000 |
| Korea, Republic of | | 13 | 107 | -- | -- |
| United Kingdom | | 211 | 1,390 | 198 | 1,630 |
| Other | | 34 | 519 | 5 | 54 |
| Total | | 3,590 | 30,900 | 3,690 | 37,500 |

See footnotes at end of table.

TABLE 7--Continued
U.S. IMPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY¹

| Product and country | HTS code ² | 2002 | | 2003 | |
|----------------------|-----------------------|---------------------------|----------------------|---------------------------|----------------------|
| | | Quantity (metric tons) | Value (thousands) | Quantity (metric tons) | Value (thousands) |
| Other, gross weight: | Various ⁵ | | | | |
| Austria | | 238 | \$6,790 | 149 | \$5,440 |
| Canada | | (⁶) | 22 | (⁶) | 16 |
| China | | 398 | 4,060 | 345 | 4,330 |
| Germany | | 66 | 1,720 | 61 | 1,320 |
| Hong Kong | | 50 | 470 | 41 | 346 |
| Japan | | 16 | 643 | 28 | 1,190 |
| Korea, Republic of | | (⁶) | 4 | -- | -- |
| Russia | | 19 | 1,140 | 19 | 1,110 |
| United Kingdom | | 8 | 306 | 10 | 272 |
| Other | | 84 ^r | 890 ^r | 60 | 1,410 |
| Total | | 879 ^r | 16,000 | 713 | 15,400 |

^rRevised. -- Zero.

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

²Harmonized Tariff Schedule of the United States.

³Includes HTS codes 2841.70.1000 and 2841.70.5000.

⁴Ferromolybdenum contains about 60% to 65% molybdenum.

⁵Includes HTS codes 8102.10.0000, 8102.94.0000, 8102.95.3000, 8102.95.6000, 8102.96.0000, 8102.97.0000, and 8102.99.0000.

⁶Less than 1/2 unit.

Source: U.S. Census Bureau.

TABLE 8
U.S. IMPORTS OF MOLYBDENUM ORE AND CONCENTRATES (INCLUDING
ROASTED AND OTHER CONCENTRATES), BY COUNTRY¹

| Country | 2002 | | 2003 | |
|-------------|---|----------------------|---|----------------------|
| | Quantity (metric tons of contained molybdenum) | Value (thousands) | Quantity (metric tons of contained molybdenum) | Value (thousands) |
| Belgium | 19 | \$132 | 22 | \$172 |
| Canada | 2,290 | 18,100 | 2,580 | 23,600 |
| Chile | 109 | 873 | 280 | 3,270 |
| China | 142 | 1,340 | 57 | 513 |
| Italy | 2 | 25 | -- | -- |
| Japan | -- | -- | 3 | 15 |
| Mexico | 2,150 | 16,300 | 2,250 | 23,700 |
| Netherlands | (²) | 2 | -- | -- |
| Total | 4,710 | 36,800 | 5,190 | 51,300 |

-- Zero.

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

²Less than 1/2 unit.

Source: U.S. Census Bureau.

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

| Item | HTS code ² | 2002 | | | 2003 | | |
|--|-----------------------|-------------------------------|--|----------------------|-------------------------------|--|----------------------|
| | | Gross weight (metric tons) | Contained molybdenum (metric tons) | Value (thousands) | Gross weight (metric tons) | Contained molybdenum (metric tons) | Value (thousands) |
| Molybdenum ore and concentrates, roasted | 2613.10.0000 | 7,030 | 4,370 | \$33,300 | 6,310 | 3,960 | \$41,800 |
| Molybdenum ore and concentrates, other | 2613.90.0000 | 664 | 340 | 3,440 | 2,870 | 1,230 | 9,570 |
| Molybdenum chemicals: | | | | | | | |
| Oxides and hydroxides | 2825.70.0000 | 1,210 | NA | 7,500 | 1,300 | NA | 9,600 |
| Molybdates, all | Various ³ | 2,170 | 1,100 ^r | 12,500 | 1,940 | 1,080 | 12,600 |
| Molybdenum orange | 3206.20.0020 | 1,300 | NA | 5,330 | 987 | NA | 4,310 |

See footnotes at end of table.

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

| Item | HTS code ² | 2002 | | | 2003 | | |
|------------------------------------|-----------------------|-------------------------------|--|----------------------|-------------------------------|--|----------------------|
| | | Gross weight (metric tons) | Contained molybdenum (metric tons) | Value (thousands) | Gross weight (metric tons) | Contained molybdenum (metric tons) | Value (thousands) |
| Ferromolybdenum | 7202.70.0000 | 5,570 | 3,590 | \$30,900 | 5,740 | 3,690 | \$37,500 |
| Molybdenum powders | 8102.10.0000 | 39 | 32 | 1,080 | 57 | 43 | 1,950 |
| Molybdenum unwrought, bar and rods | 8102.94.0000 | 43 | 43 | 531 | 139 | 136 | 1,680 |
| Molybdenum waste and scrap | 8102.97.0000 | 697 | 617 | 6,810 | 425 | 388 | 4,900 |
| Molybdenum wire | 8102.96.0000 | 15 | NA | 674 | 11 | NA | 751 |
| Molybdenum, other | Various ⁴ | 85 | NA | 6,940 | 80 | NA | 6,160 |
| Total | | 18,800 | 10,100 | 109,000 | 19,900 | 10,500 | 131,000 |

^rRevised. NA Not available.

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

²Harmonized Tariff Schedule of the United States.

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-PRODUCING MINES IN THE UNITED STATES IN 2003¹

| State and mine | County | Operator | Source of molybdenum |
|--------------------------|-------------|-----------------------------|--------------------------------------|
| Arizona: | | | |
| Bagdad | Yavapai | Phelps Dodge Corp. | Copper-molybdenum ore, concentrated. |
| Sierrita | Pima | do. | Do. |
| Colorado, Henderson | Clear Creek | do. | Molybdenum ore, concentrated. |
| Idaho, Thompson Creek | Custer | Thompson Creek Metals Co. | Do. |
| Montana, Continental Pit | Silver Bow | Montana Resources | Copper-molybdenum ore, concentrated. |
| New Mexico, Questa | Taos | Molycorp, Inc. | Molybdenum ore, concentrated. |
| Utah, Bingham Canyon | Salt Lake | Kennecott Utah Copper Corp. | Copper-molybdenum ore, concentrated. |

TABLE 11
MOLYBDENUM: WORLD MINE PRODUCTION, BY COUNTRY^{1,2}

(Metric tons of contained molybdenum)

| Country ³ | 1999 | 2000 | 2001 | 2002 | 2003 ^c |
|-------------------------|------------------|----------------------|----------------------|----------------------|---------------------|
| Armenia ^c | 2,800 | 3,100 | 3,400 | 3,500 | 3,500 |
| Canada | 6,250 | 7,457 ^r | 8,556 ^r | 7,521 | 7,500 |
| Chile | 27,309 | 33,187 | 33,492 | 29,466 | 30,000 |
| China ^c | 29,700 | 28,800 | 28,200 | 29,300 | 30,600 |
| Iran ^c | 1,600 | 1,600 | 1,500 ^r | 1,400 ^r | 1,400 |
| Kazakhstan | 155 | 215 | 225 | 230 | 230 |
| Kyrgyzstan ^c | 250 ⁴ | 250 | 250 | 250 | 250 |
| Mexico | 7,961 | 6,886 | 5,518 | 3,428 | 3,523 ⁴ |
| Mongolia | 1,910 | 1,335 | 1,514 | 1,590 | 1,600 |
| Peru | 5,470 | 7,190 | 9,500 | 8,616 ^r | 9,632 ⁴ |
| Russia ^c | 2,400 | 2,400 | 2,600 | 2,900 | 2,900 |
| United States | 42,400 | 40,900 | 37,600 | 32,000 ^r | 33,500 ⁴ |
| Uzbekistan ^c | 500 | 500 | 500 | 500 | 500 |
| Total | 129,000 | 134,000 ^r | 133,000 ^r | 121,000 ^r | 125,000 |

^cEstimated. ^rRevised.

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

²Table includes data available through July 13, 2004.

³In addition to the countries listed, North Korea, Romania, and Turkey are believed to produce molybdenum, but output is not reported quantitatively, and available general information is inadequate to make reliable estimates of output levels.

⁴Reported figure.