MOLYBDENUM

By John W. Blossom

Molybdenum is a refractory metallic element used principally as an alloying agent in steels, cast irons, and superalloys to enhance hardenability, strength, toughness, and wear and corrosion resistance. Primarily added in the form of molybdic oxide or ferromolybdenum, it is frequently used in combination with chromium, columbium, manganese, nickel, tungsten, or other alloy metals to achieve desired metallurgical properties. The versatility of molybdenum has ensured it a significant role in contemporary technology and industry, which increasingly require materials that are serviceable under higher stresses, greater temperature ranges, and more corrosive environments. Moreover, molybdenum finds significant usage 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 substitutions, has resulted in a demand that is expected to grow at a greater rate than most other ferrous metals.

Distribution of molybdenum reserves and productive capacity is concentrated in a few countries of the world. World mine output was an estimated 104,000 metric tons (molybdenum contained in concentrate) in 1994, of which Canada, Chile, China, and the United States provided 86%. These four countries, led by the United States, are expected to continue as the principal mine producers for the rest of this century. These countries also possess about 90% of the estimated 12 million metric tons of molybdenum in world reserve base.

The metric system is the official system of measurement of most countries. The U.S. Bureau of Mines (USBM), in an effort to provide statistical data on molybdenum that are consistent with international usage, reports data in kilograms and metric tons.

Domestic production data for molybdenum are developed by the USBM by means of three separate, voluntary surveys. These surveys are Molybdenum Ore and Concentrate, Molybdenum Concentrate and Molybdenum Products, and Molybdenum Concentrates. Surveys are sent to all operations that produce molybdenum ore and products. Out of 10 operations to which surveys were sent, all responded, representing 100% of the total U.S. production shown in table 1.

Domestic mine production of molybdenum concentrate increased to a total of 46,800 tons of contained molybdenum compared with 36,800 tons in 1993. This production was about 45% of world production. World mine production of molybdenum concentrate increased from a total of 93,600 tons in 1993 to 104,000 tons in 1994. Canada, Chile, China, Russia, and the United States accounted for an estimated 86% of the molybdenum produced worldwide. Production of molybdenum products increased 37% in 1994. *(See tables 1, 2, and 3.)*

Consumption

Consumption of molybdenum concentrate increased 3,400 tons in 1994. Domestic mine production of molybdenum concentrate was either roasted, exported for conversion, or purified to lubrication-grade molybdenum disulfide. The consumption in 1994 of technical-grade molybdic oxide increased about 11% from that of 1993. Oxide is the chief form of molybdenum utilized by industry, particularly in stainless and alloy steel, cast iron, and superalloys. However, some of the material is also converted to other molybdenum products, such as ferromolybdenum, high-purity oxide, ammonium and sodium molybdate, and metal powder. *(See table 4.)*

Stocks

Total industry stocks, which include those of producers and consumers, decreased by about 8,400 tons of contained molybdenum. Inventories of molybdenum in concentrate at producer locations decreased about 5,690 tons. Producer stocks of molybdenum in products, such as oxide, ferromolybdenum, molybdate, metal powders, and other types, decreased by about 2,210 tons. Domestic end-use consumer stocks of molybdenum decreased 400 tons from that in 1993. Inventories of 2,100 tons represented approximately a 7-week supply as measured by the average monthly reported consumption.

Prices

Prices are from Platt's Metals Week and are in U.S. dollars per kilogram of contained molybdenum. The prices at the beginning of 1994 were: molybdenum concentrates (MoCons), $3.803; molybdic oxide (MoX), $6.025; and ferromolybdenum (Femo), $7.496. The prices at the beginning of the second quarter were: MoCons, $3.803; MoX, $6.746; and Femo, $8.230. The prices at the start of the third quarter were: MoCons, $6.008; MoX, $7.716; and Femo, $9.425. The prices at the start of the fourth quarter were: MoCons, $8.157; MoX, $10.280; and Femo, $10.748. The prices at the end of the fourth quarter were: MoCons, $8.708; MoX, $32.077; and Femo, $29.321. The average prices for 1994 were: MoCons, $2.531; MoX, $4.604; and Femo, $5.134.

Foreign Trade

Exports of molybdenum in concentrate and in molybdic oxide increased about 19% when compared with those of 1993. Molybdenum concentrate exports were about 72% of domestic mine production. Approximately 92% of reported exports of concentrate and oxides were made to Belgium, Canada, Chile, Japan, the Netherlands, and the United Kingdom. The calculated molybdenum content of all exports was about 38,600 tons in 1994. Total value of exports increased from $108 million in 1993 to $247 million in 1994.

Approximately 7,200 tons of molybdenum in various forms was imported into the United States, about the same as in 1993. Total value of all forms of molybdenum imported increased from $48 million in 1993 to $59 million in 1994. In terms of both value and quantity, the major form imported was ferromolybdenum. *(See tables 5, 6, and 7.)*

World Review

Capacity.—The rated capacity for mines and mills as of December 31, 1994, was 125,000 tons per year 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 labor, energy, materials, and maintenance. Capacity includes both operating plants and plants temporarily closed

that, in the judgment of the author, can be brought into production within a short period of time with minimum capital expenditure. Mine capacity for molybdenum is based on published reports, production statistics, and estimates.

Reserves.—The definitions of reserves and reserve base are published in U.S. Geological Survey Circular 831, "Principles of a Resource/Reserve Classification For Minerals," which is reprinted in the USBM Mineral Commodity Summaries, 1991.

The United States, with a reserve base of molybdenum estimated at 11.8 million tons, has 45% of the world molybdenum reserve base. About 90% of U.S. reserves occur in large porphyry or disseminated deposits mined, or anticipated to be mined, primarily for molybdenum. These deposits are in Alaska, Colorado, Idaho, Nevada, New Mexico, and Utah. Other molybdenum sources contribute insignificantly to U.S. reserves.

Canadian reserves of primary molybdenum are in British Columbia, including 30% of the total in the Endako primary deposit. Other Canadian reserves are associated with molybdenum and copper-molybdenum porphyry deposits in British Columbia and in relatively minor sources in Quebec and New Brunswick.

Molybdenum reserves in Central and South America are mainly in large copper porphyry deposits. Of several such deposits in Chile, the Chuquicamata and El Teniente deposits are among the world's largest and account for 85% of total molybdenum reserves in Chile. Mexico and Peru have substantial reserves. The La Caridad deposit in Mexico is a large producer. Numerous other copper porphyries that may contain recoverable quantities of molybdenum have been identified in Central and South America. Many of these deposits are actively being explored and evaluated and could add substantially to reserves in the future.

Reserves of molybdenum in China and the former U.S.S.R. are estimated to be substantial, but definitive information about the current sources of supply or prospects for future development in the two countries is lacking. Copper ores are being investigated on the islands of New Guinea and Bougainville in the southwest Pacific, but it is not known whether these contain economically recoverable molybdenum.

Outlook

The world demand for molybdenum contained in alloy and stainless steel and also for chemicals/catalysts is expected to increase 4% to 6% in 1995. It is estimated that the growth in demand will drop to 3% to 5% in 1996. Projecting into 1997, molybdenum demand may see a growth of 6% to 8%.

OTHER SOURCES OF INFORMATION

U.S. Bureau of Mines Publications

Molybdenum. Ch. in Minerals Commodity Summaries, annual.

Molybdenum. Ch. in Minerals Yearbook, annual.

Molybdenum. Reported monthly and annually in Mineral Industry Surveys.

Other Sources

American Bureau of Metal Statistics. Nonferrous Metal Data.

American Metal Market (daily paper).

Canadian Mining Journal (Canada). Annual reports of various companies.

Engineering and Mining Journal.

Metal Bulletin (London).

Metals Week.

Mining Congress Journal.

Mining Engineering.

Mining Journal (London).

Skillings' Mining Review.

The Northern Miner (Canada).

TABLE 1
SALIENT MOLYBDENUM STATISTICS 1/

(Metric tons of contained molybdenum unless otherwise specified)

	1990	1991	1992	1993	1994
United States:					
Concentrate:					
Production	61,600	53,400	49,700	36,800	46,800
Shipments	61,600	53,600	45,100	39,200	46,000
Value thousands	$346,000	$250,000	$190,000	$165,000	$284,000
Reported consumption	35,500	33,000	15,200	13,800	17,200
Imports for consumption	478	161	831	3,400	2,280
Stocks, Dec. 31:					
Concentrate, mine and plant	7,670	5,290	11,900	11,200 r/	5,510
Product producers 2/	5,920	9,420	7,480	6,150	3,940
Consumers, by end use	2,580 r/	2,590	2,500	2,520	2,080
Total	16,200	17,300	21,900	19,900 r/	11,500
Primary products:					
Production	28,800	33,700	26,000	22,700	31,100
Shipments	18,000	19,100	17,300	16,000	21,400
Reported consumption, by end use	18,100	16,900	17,200	17,700	19,100
World: Mine production	127,000	115,000	108,000	93,600 r/	104,000 e/

e/ Estimated. r/ Revised.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes technical and purified molybdic oxide, briquets, ferromolybdenum, phosphomolybdic acid, molybdenum disulfide, molybdic 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 STATES 1/

(Metric tons of contained molybdenum)

	1993	1994	1993	1994	1993	1994
	Metal powder		Other 2/		Total	
Received from other producers	--	--	4,320	4,030	4,320	4,030
Gross production during year	1,580	2,570	21,100	28,600	22,700	31,100
Molybdenum products used to make other products	286	1,500	10,400	13,600	10,700	15,100
Net production	1,290	1,070	10,700	14,900	12,000	16,000
Shipments	419	214	15,600	21,200	16,000	21,400
Producer stocks, Dec. 31	101	124	6,050	3,820	6,150	3,940

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes 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
MOLYBDENUM: WORLD MINE PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons of contained molybdenum)

Country 3/	1990	1991	1992	1993	1994 e/
Armenia e/	XX	XX	1,000	500	500
Bulgaria e/	150	120	120	120	100
Canada	12,000	11,300	9,410	9,700 r/	9,540 4/
Chile	13,600 r/	14,400	14,800	14,900 r/	16,000 4/
China e/	15,700	13,200	19,200 r/	18,300 r/	17,500
Iran	542	395	847 r/	1,000 r/ e/	1,000
Kazakhstan e/	XX	XX	700 r/	600 r/	500
Korea, Republic of	103	144	--	--	--
Mexico	2,000 e/	1,720	1,460	1,710	2,610 4/
Mongolia	1,580	1,720	1,520	1,500 e/	1,500
Niger e/	10	10	--	--	
Peru	2,510	3,030	3,220	2,980 r/	3,000
Russia e/	XX	XX	5,000	4,800	4,500
U.S.S.R. e/ 5/	17,000	16,000	XX	XX	XX
United States	61,600	53,400	49,700	36,800	46,800 4/
Uzbekistan e/	XX	XX	700 r/	700 r/	700
Total	127,000	115,000	108,000	93,600 r/	104,000

e/ Estimated. r/ Revised. XX Not applicable.

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Table includes data available through June 13, 1995.

3/ In 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.

4/ Reported figure.

5/ Dissolved in Dec. 1991.

TABLE 4
U.S. REPORTED CONSUMPTION OF MOLYBDENUM, BY END USE 1/

(Kilograms, contained molybdenum)

End use	Molybdic oxides	Ferro-molybdenum 2/	Ammonium and sodium molybdate	Molybdenum scrap	Other 3/	Total
1993						
Steel:						
Carbon	659,000	175,000	--	--	68,300	902,000
Stainless and heat-resisting	2,840,000	210,000	--	--	57,600	3,100,000
Full alloy	2,380,000	1,120,000	--	--	13,100	3,510,000
High-strength low-alloy	451,000	346,000	--	--	--	798,000
Tool	597,000	W	--	--	8,240	605,000
Cast irons	83,000	739,000	--	--	14,600	837,000
Superalloys	W	W	--	--	889,000	889,000
Alloys:				--		
Welding materials (structural and hard-facing)	--	93,900 r/	--	--	6,380	100,000
Other alloys 4/	W	W	--	--	54,100 r/	54,100 r/
Mill products made from metal powder	--	--	--	--	1,760,000	1,760,000
Chemical and ceramic uses:				--		
Pigments	W	--	W	--	--	W
Catalysts	1,650,000	--	W	--	179,000	1,830,000
Other	W	(5/)	W	--	315,000	315,000
Miscellaneous and unspecified	1,080,000	415,000	1,420,000	--	96,600	3,020,000 r/
Total	9,740,000	3,100,000	1,420,000	--	3,460,000	17,700,000
1994						
Steel:						
Carbon	668,000	303,000	--	--	76,900	1,050,000
Stainless and heat-resisting	3,310,000	537,000	--	--	43,300	3,890,000
Full alloy	2,460,000	1,180,000	--	--	31,300	3,670,000
High-strength low-alloy	518,000	307,000	--	--	--	825,000
Tool	788,000	W	--	--	W	788,000
Cast irons	199,000	773,000	--	--	14,200	986,000
Superalloys	W	W	--	W	618,000	618,000
Alloys:						
Welding materials (structural and hard-facing)	--	88,200	--	--	6,900	95,100
Other alloys 4/	W	W	--	--	74,200	74,200
Mill products made from metal powder	W	W	--	--	1,630,000	1,630,000
Chemical and ceramic uses:						
Pigments	W	--	W	--	--	W
Catalysts	1,710,000	--	W	--	179,000	1,890,000
Other	W	--	W	--	299,000	299,000
Miscellaneous and unspecified	1,100,000	258,000	1,280,000	481,000	158,000	3,280,000
Total	10,800,000	3,440,000	1,280,000	481,000	3,130,000	19,100,000

r/ Revised. W Withheld to avoid disclosing company proprietary data; included in "Miscellaneous and unspecified."

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

2/ Includes calcium molybdate.

3/ Includes purified molybdenum disulfide, molydenite concentrate added directly to steel, molybdenum metal powder, molybdenum metal, pellets and other molybdenum materials.

4/ Includes magnetic and nonferrous alloys.

5/ Revised to zero.

TABLE 5
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY 1/

Product and country	HTS NO.	1993		1994	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Oxides and hydroxides, gross weight:	2825.70.0000				
Belgium		154	$720	164	$787
Brazil		--	--	34	168
Canada		199	1,330	414	3,330
China		--	--	183	429
India		--	--	38	154
Japan		525	2,850	505	3,380
Korea, Republic of		17	77	--	--
Mexico		--	--	10	278
Netherlands		77	353	558	3,330
Netherlands Antilles		--	--	109	821
United Kingdom		47	155	225	1,030
Venezuela		23	124	(2/)	9
Total		1,040	5,610	2,240	13,700
Molybdates all, contained weight:	2841.70.0000				
Canada		526 r/	2,460	437	2,200
Honduras		2	15	5	33
Indonesia		7	16	--	--
Jamaica		1	6	1	8
Japan		152	726	156	751
Korea, Republic of		110	512	113	552
Mexico		73	315	45	300
Netherlands		38	482	779	5,170
Netherlands Antilles		--	--	178	658
Pakistan		2	15	--	--
Philippines		(2/)	6	12	18
Singapore		2	11	1	9
Taiwan		39 r/	177 r/	66	234
Thailand		(2/)	3	6	44
Other		6 r/	39 r/	3	15
Total		958	4,790 r/	1,800	10,000
Ferromolybdenum, contained weight: 3/	7202.70.0000				
Argentina		--	--	17	179
Canada		60	593	113	1,260
Japan		41	616	93	1,090
Malaysia		76	1,120	6	92
Mexico		20	239	152	1,350
Netherlands		--	--	56	452
Singapore		16	232	12	338
Taiwan		9	127	28	408
Venezuela		2 r/	32	2	26
Other		(4/)	(4/)	(2/)	6
Total		224	2,960	479	5,200
Powder, gross weight:	8102.10.0000				
Belgium		1	5	13	443
Brazil		8	118	3	106
Canada		5	189	7	231
France		4	145	14	432
Germany		5	249	7	391
India		15	247	16	268
Italy		1	51	1	58
Japan		11	324	11	232
Mexico		16	399	9	284
Netherlands		1	32	3	117
Spain		(2/)	49	2	123
Sweden		18	286	5	77
Switzerland		(2/)	37	5	110
Taiwan		72	1,350	66	1,250
Turkey		1	69	(2/)	12
United Kingdom		45	210	3	113
Other		(2/) r/	116 r/	3	78
Total		203 r/	3,760 r/	168	4,320

See footnotes at end of table.

TABLE 5 -- CONTINUED
U.S. EXPORTS OF MOLYBDENUM PRODUCTS, BY PRODUCT AND COUNTRY 1/

Product and country	HTS No.	1993		1994	
		Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
Molybdenum unwrought, gross weight:	8102.91.0000				
Australia		1	$11	10	$102
Austria		--	--	38	598
Canada		7	87	23	403
France		9 r/	163	4	117
Germany		5	33	--	--
Hong Kong		--	--	6	72
India		4 r/	56	2	22
Japan		1	12	85	1,050
Korea, Republic of		--	--	3	51
Mexico		(2/)	6	1	35
Netherlands		25	423	170	2,020
Netherlands Antilles		--	--	36	290
Sweden		--	--	9	71
United Kingdom		(2/)	3	9	141
Other		(2/) r/	5 r/	(2/)	15
Total		52	801	396	4,980
Molybdenum wrought, gross weight:	8102.92.0000				
Brazil		(2/)	25	2	82
Canada		8 r/	393	9	409
France		24 r/	975	18	782
Germany		6	484 r/	3	283
India		(2/)	46	1	114
Italy		1	47	1	80
Japan		14	1,280	34	2,510
Korea, Republic of		(2/)	59	2	220
Mexico		3	87	1	125
Netherlands		1	135	1	20
United Kingdom		31	1,060	26	1,190
Other		4 r/	202 r/	3	245
Total		94 r/	4,790	103	6,050
Wire, gross weight:	8102.93.0000				
Argentina		2	66	3	130
Belgium		1 r/	52	1	50
Brazil		24 r/	947	21	744
Canada		5 r/	176 r/	2	105
Czech, Republic		--	--	3	85
France		17 r/	606 r/	25	911
Germany		61 r/	1,990	51	1,890
Hungary		27	1,050	31	1,790
India		14	720	11	673
Italy		14	526	13	544
Japan		38 r/	1,510	12	747
Korea, Republic of		16	737 r/	14	621
Mexico		11 r/	519	6	501
Netherlands		--	--	1	14
Poland		--	--	1	47
Singapore		6	234	3	102
Spain		3	110 r/	5	155
Sweden		3 r/	112 r/	5	162
Taiwan		5 r/	235	7	301
United Kingdom		4	168	5	239
Other		12 r/	453 r/	2	234
Total		261 r/	10,200 r/	221	10,000

r/ Revised.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.
3/ Ferromolybdenum contains about 60% to 65% molybdenum.
4/ Revised to zero.

Source: Bureau of the Census.

TABLE 6
U.S. EXPORTS OF MOLYBDENUM ORE AND CONCENTRATES (INCLUDING ROASTED AND OTHER CONCENTRATES), BY COUNTRY 1/

(Metric tons)

Country	1993		1994	
	Quantity (contained molybdenum)	Value (thousands)	Quantity (contained molybdenum)	Value (thousands)
Argentina	--	--	1	$6
Australia	61	$284	23	118
Austria	--	--	11	80
Belgium	6,930	6,620	11,500	78,300
Brazil	218	816	445	3,030
Canada	403	1,790	1,300	7,070
Chile	2,960	8,240	2,160	11,900
China	--	--	224	800
France	294	1,030	--	--
Germany	1,500	5,040	635	3,820
India	2	54	127	781
Italy	--	--	78	640
Japan	4,030	13,000	3,860	24,800
Korea, Republic of	--	--	7	41
Malta	--	--	53	198
Mexico	12	112	519	6,410
Netherlands	9,990	28,200	8,670	35,300
Netherlands Antilles	--	--	554	2,910
Russia	--	--	53	1,160
Singapore	--	--	2	13
Sweden	874	2,540	107	581
Switzerland	--	--	16	249
United Kingdom	976	5,580	3,290	21,000
Other	32	929	--	--
Total	28,300	74,200	33,600	199,000

1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 7
U.S. IMPORTS FOR CONSUMPTION OF MOLYBDENUM 1/

Item	HTS No.	1993			1994		
		Gross weight (metric tons)	Contained molybdenum	Value (thousands)	Gross weight (metric tons)	Contained molybdenum	Value (thousands)
Molybdenum ore and concentrates, roasted	2613.10.0000	5,800	3,370	$16,800	3,110	1,870	$12,700
Molybdenum ore and concentrates, other	2613.90.0000	40 r/	25	172	682	411	3,190
Molybdenum oxides and hydroxides	2825.70.0000	622	NA	2,880	628	NA	3,950
Molydates of ammonium	2841.70.0000	538	300	2,610	608	321	2,340
Molybdates all others	2841.70.5000	18 r/	17	28	76	41	288
Molybdenum orange	3206.20.0000	680	NA	2,040	616	NA	1,880
Mixtures of inorganic compounds	3823.90.3400	19	(2/)	154	3	2	235
Ferromolybdenum	7202.70.0000	3,480	2,190	12,700	4,590	2,960	23,200
Molybdenum powders	8102.10.0000	66	52	2,090	113	89	2,770
Molybdenum unwrought	8102.91.1000	164	136	1,750	70	52	1,060
Molybdenum waste and scrap	8102.91.5000	380	363	2,600	791	777	6,560
Molybdenum wrought (includes bars, rods, profiles, plate, sheets, strips, foil)	8102.92.0000	49	NA	3,430	--	--	--
Molybdenum wire	8102.93.0000	3	NA	308	2	NA	304
Molybdenum other	8102.99.0000	1	NA	759	5	NA	738
Total		11,900	6,460	48,300	11,300	6,520	59,300

r/ Revised. NA Not available.
1/ Previously published and 1994 data are rounded by the U.S. Bureau of Mines to three significant digits; may not add to totals shown.
2/ Less than 1/2 unit.

Source: Bureau of the Census.