

# Molybdenum

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**Robert McInnis**

*The author is with the Mining Sector,  
Natural Resources Canada.  
Telephone: (613) 992-8179*

Canada is the third largest producer of molybdenum in the world. In 1994, Canadian companies produced 9542 t (estimate) of contained molybdenum (Mo) in the form of molybdenum concentrate or oxide. Production was down slightly from the 9699 t produced in 1993. Such changes in production are more a factor of the grade of ore being mined during the year than a reaction to market forces. The value of production, however, increased to \$91 million from \$65 million.

The year 1994 was a year of phenomenal changes in world molybdenum markets. Prices that early in the year were in the range of US\$5.95-\$6.17/kg of contained molybdenum had increased to about US\$39/kg at year-end. This price change occurred as supply shifted from a surplus to a shortage. This shift is attributed to two factors: increased steel production, and a restructuring of the molybdenum industry.

World steel production boomed in 1994, increasing by over 4% in Western developed countries and by about 2.5% in developing countries. Molybdenum is a very effective alloying element and, since it was relatively low cost until this year, its use has seen a steady increase over the past decade. By year-end, some steel companies had imposed a surcharge on the molybdenum contained in the steel produced.

The restructuring of the industry included the closure of roasting and ferromolybdenum conversion facilities in both the United States and Europe, and the closure, or temporary shut-down, of primary mines in the United States. These closures were in response to the very low prices that had resulted from surplus supply. Perhaps an even more significant change was the amalgamation of the Cyprus and Amax mining companies. The new company produces about 75% of the world's primary molybdenum. This fact is very significant because it is primary molybdenum that is the variable supply. The only other primary producer, Placer Dome's Endako mine, has operated at capacity for many years, therefore not functioning in the role of swing producer.

The effect of this restructuring of the industry was somewhat lessened during 1992 and 1993 because China had sold greater-than-normal amounts of molybdenum, possibly from inventories collected for national defence purposes. In 1994, Chinese molybdenum effectively disappeared from the world market. The Chinese steel industry is in a period of rapid growth and domestic consumption of molybdenum was, in 1994, equal to or perhaps greater than domestic supply. There is some evidence that China's molybdenum capacity has declined.

Another factor that maintained the excess supply that characterized the industry prior to 1994 was a reduction in the quantity of molybdenum imported by Russia and other countries that were part of the former Soviet Union. This market area has virtually no domestic supply and historically imported a considerable quantity of molybdenum. During the last two years of economic crisis, imports fell dramatically, thereby reducing the impact of a tightening world supply.

Steel production is not the only use of molybdenum that has been growing. Another area is its use as a catalyst in a process that removes sulphur from crude oil in refineries. With efforts to protect the environment, this is a market that has seen considerable growth.

Western World production and withdrawals from inventories, including imports from Iran, the C.I.S., China and Mongolia, were estimated at 89 700 t in 1994, slightly less than in 1993 when production was 90 100 t. These levels illustrate the decline in production that resulted from historically very low prices associated with low demand from the world steel industry facing recession-induced low steel production. About 75% of world molybdenum is produced as a by-product of copper mining. This production is price-inflexible and is generally sold for whatever the market offers. In fact, the supply of by-product molybdenum is really a function of the demand for, and price of, copper. Thus, since demand for copper remained high during the recession, most of the decline in production came from the temporary shut-down or permanent closure of primary molybdenum mines. In 1994, with economic recovery well under way in the United States and starting in Europe, a shortage of molybdenum quickly developed. At year-end, some primary producers had indicated they

would be increasing production. Kennecott of the United States announced plans to increase production from 8200 t in 1994 to 10 400 t in 1995.

The United States remained the world leader in molybdenum production in 1994 with total production estimated at 44 700 t, followed by Chile at 15 800 t.

World demand for molybdenum in 1994 is estimated at 99 800 t, up almost 5% from the 1993 level. At year-end, North American demand for steel remained high with the potential for even higher demand in 1995. Molybdenum demand will remain high, supporting relatively high prices. In the longer term, these higher consumption levels are expected to persist because alternative alloying elements are also quite high in price. Also, the primary producers will likely increase production, thereby moderating price increases so that substitution does not become a significant factor. Although prices are expected to moderate from the very high levels of year-end, the new equilibrium prices will be considerably higher than in the past, possibly in the range of US\$15-\$22/kg. The surplus supply that had depressed the price for the past five or six years is unlikely to reappear in the medium term.

## THE CANADIAN INDUSTRY

Canada has three operating molybdenum mines: one is a primary producer, and two are by-product or co-product producers. A third copper mine operated by Gibraltar Mines is expected to restart its molybdenum recovery circuit.

The Endako mine, 100% owned by Placer Dome Inc., is the primary producer. Endako, located at Fraser Lake, British Columbia, is the world's lowest-cost primary producer at a production cost of less than US\$5.00/kg. Operations started in 1962, but the mine closed in June 1986. It re-opened in 1988 and capacity operation was achieved in October of that year. The mine has reserves of about 70 Mt of ore grading 0.082% molybdenum. Placer Dome has two roasters with a total capacity of 10 800 t/y. In 1988, the company invested \$2.2 million to double its mine-site ultrapure lubricant-grade molybdenum disulfide capacity to 450 t/y.

The following mines produce by-product molybdenum:

- Gibraltar Mines, at McLeese Lake, British Columbia, is owned 68.1% by Placer Dome. Reserves are about 76 Mt of proven and probable ore and 229 Mt of measured and indicated ore. The proven ore grades 0.31% copper and 0.009% molybdenum. In recent years, production of molybdenum was stopped because of the low price of molybdenum and because the ore being mined was harder with lower molybdenum grades. The

harder ore also results in lower molybdenum recovery rates. The mine was closed between November 1993 and September 1994 because of low copper prices. In 1995 the ore being mined will be of higher grade, and the company plans to refurbish the molybdenum recovery circuit with start-up scheduled for mid-year.

- Highland Valley Copper, at Highland Valley, British Columbia, is a joint venture with the following ownership: Cominco Ltd., 50%; Rio Algom, 33.6%; Teck Corp., 13.9%; and Highmont Mining Company, 2.5%. Reserves are 750 Mt grading 0.41% copper and 0.008% molybdenum. In 1991, Highland Valley Copper produced 900 t of molybdenum concentrate.
- BHP Minerals Canada Ltd. is the sole owner of the Island Copper mine located at Port Hardy, British Columbia. The open-pit copper mine has ore grading 0.4% copper and 0.02% molybdenum. It is a significant producer of molybdenum with annual production levels of about 2500 t of contained molybdenum. This deposit is nearing the end of its economic life and the mine will likely be closed in the near future.

Canadian molybdenum production has been at very similar levels since 1992 because the three producing mines have operated at capacity.

The Endako operation has also obtained profitable results from its molybdenum upgrading facilities. These facilities have been especially valuable since the Molycorp roaster in the state of Washington was closed in 1991.

## U.S. DEVELOPMENTS

In the United States, the most significant development was the amalgamation of the mining operations of Cyprus Minerals Co. and Amax Gold Inc. The new company, Cyprus Amax Minerals Company, is now the producer of most of the primary molybdenum in the United States.

## USES

Molybdenum and its compounds have a number of diverse uses. It is used as a pure metal, as an alloy additive, as a lubricant, as a catalyst, and in a number of chemical compounds. In order of market share, these uses are described below.

### The Alloying Element

Molybdenum is a very versatile and cost-effective alloying element. It is added to steel and ferrous castings as molybdenic oxide ( $\text{MoO}_3$ ) or as ferromolybdenum. Ferromolybdenum is an alloy of iron and

molybdenum. In this form, molybdenum is readily dissolved in molten steel with very little loss; therefore, ferromolybdenum is often used in making fine adjustments to the chemistry of batches of steel.

## The Metal

Molybdenum metal is the product of a rather sophisticated refining process. The metal oxide is refined to high levels of purity by precipitation from solution. The oxide powder is then reduced in hydrogen and the metal powder is compressed into billets prior to required forming operations. Molybdenum metal has a number of valuable properties. Specifically, it has a low coefficient of thermal expansion, the refractory property of a high melting temperature, corrosion resistance, low levels of erosion from molten metal, low density, relatively high thermal conductivity, low specific heat, a high modulus of elasticity, and relatively high electrical conductivity and good electrical contact properties.

## The Chemical

Molybdenum is an element that is an important component of a wide variety of chemicals. These chemicals are used as lubricants, reagents, dyeing compounds, pigments, vitreous glazes and enamels, electroplating compounds, catalysts, fertilizers, flame retardants, and paints and inks.

## Other Uses

Molybdenum is valued for its properties as a catalyst in the petroleum refining and chemical processing industries. Pure molybdenum disulfide is an excellent dry lubricant because it has a lamellar structure with a low coefficient of friction between the laminations and the property of bonding to other materials. Molybdenum can also be used in the production of rechargeable dry batteries. These lithium-molybdenum batteries have more power per cell volume than conventional nickel-cadmium or alkaline batteries.

## PRICES

The Canadian price for contained molybdenum in concentrate averaged C\$6.35/kg in 1993 and was estimated at C\$9.32/kg in 1994.

On the world market, the spot price for molybdenum oxide averaged US\$4.87/kg in 1992, and in 1994 averaged US\$6.28-\$6.94/kg in the first quarter and closed the year at US\$44.09/kg (Codelco of Chile).

## OUTLOOK

Molybdenum prices are likely to remain high in 1995 and 1996. High inventories that hung over the marketplace have disappeared and, with the increased demand that developed in the second half of 1994, demand soon exceeded supply. World demand for steel, the production of which accounts for about 75% of molybdenum consumption, is expected to grow at 1-2%/y over the next five years. Another important market for molybdenum is in the production of super-alloys, a high percentage of which are used in the aerospace industry.

In the longer term, over the next five to ten years, the demand for molybdenum should continue to increase. This expectation of higher consumption is reasonable because, even at prices of US\$17-\$22/kg, molybdenum is a bargain alloying element compared to alternative elements. The expected long-term availability of molybdenum at considerably higher, but still competitive, prices, in combination with its versatile performance, should result in a continuing increase in its use.

Canadian molybdenum production is forecast to increase slightly in 1995 as production from the Gibraltar mine re-enters the market. In the longer term, production may well decline with the expected depletion of the orebody at the Island Copper mine. Prices are expected to stabilize at higher levels as supply and demand become more balanced.

Meeting the anticipated demand is not likely to be a problem for the industry as the primary producers in the United States have the needed capacity and there is potential to recover more by-product molybdenum at copper mines that are not now operating recovery lines. There are a number of copper ore deposits that contain molybdenum and, as these are developed, molybdenum recovery facilities will likely be installed if prices remain relatively high.

*Notes: (1) For definitions and valuation of mineral production, shipments and trade, please refer to Chapter 60. (2) Information in this review was current as of February 1, 1995.*

## TARIFFS

Item No.	Description	Canada			United States	E.U.	Japan <sup>1</sup>
		MFN	GPT	USA	Canada	MFN	GATT
2613	Molybdenum ores and concentrates						
2613.10	Roasted	Free	Free	Free	3.9%/kg on molybdenum content + 0.5%	Free	Free
2613.90	Other	Free	Free	Free	Free	Free	Free
2825.70.10	Molybdenum oxides	11.8%	8%	Free	Free	5.3%	3.7%
2825.70.20	Molybdenum hydroxides	Free	Free	Free	Free	5.3%	3.7%
28.41	Salts of oxometallic or peroxometallic acids						
2841.70	Molybdates	8.5%	6%	Free	Free	6.6%	4.9%
7202.70	Ferromolybdenum	9.5%	6.5%	Free	Free	4.9%	4.9%
8102.10	Molybdenum powders						
8102.10.10	Not alloyed	3.7%	Free	Free	Free	–	3.7%
8102.10.20	Alloyed	8.8%	6.5%	Free	Free	–	3.7%
8102.91	Unwrought molybdenum, including bars and rods obtained simply by sintering; waste and scrap						
8102.91.10	Unwrought molybdenum, not alloyed	3.7%	Free	Free	Free	5%	3.7%
8102.91.20	Unwrought molybdenum, alloyed; waste and scrap	8.8%	6.5%	Free	Free	5%	3.7%
8102.92	Bars and rods, other than those obtained simply by sintering, profiles, plates, sheets, strip and foil	8.8%	6.5%	Free	Free	8%	4.9%
8102.93	Wire						
8102.93.10	Molybdenum wire, not coated or covered	7%	5%	Free	Free	8%	4.9%
8102.93.20	Molybdenum wire, coated or covered	8.8%	6.5%	Free	Free	8%	4.9%
8102.99	Other	8.8%	6.5%	Free	Free	10%	4.9%

Sources: Customs Tariff, effective January 1995, Revenue Canada; Harmonized Tariff Schedule of the United States, 1995; The "Bulletin International des Douanes," Journal Number 14 (16th Edition), European Economic Community, 1992-1993, "Conventional" column; 1st Supplement to Journal No. 14 (16th Edition), European Economic Community, 1993-1994, "Conventional" column; Custom Tariff Schedules of Japan, 1994.

– No conventional duty exists.

<sup>1</sup> GATT rate is shown; lower tariff rates may apply circumstantially.

**TABLE 1. CANADA, MOLYBDENUM PRODUCTION AND TRADE, 1992-94, AND CONSUMPTION, 1992 AND 1993**

Item No.	1992		1993		1994P	
	(tonnes)	(\$000)	(tonnes)	(\$000)	(tonnes)	(\$000)
<b>PRODUCTION (Shipments)<sup>1</sup></b>						
British Columbia	8 870	52 253	10 250	65 095	9 723	90 651
Total	8 870	52 253	10 250	65 095	9 723	90 651
<b>EXPORTS</b>						
2613.10	Molybdenum ores and concentrates, roasted					
Japan	3 634	21 991	3 871	24 086	3 202	29 363
United States	285	1 125	1 870	7 673	1 115	6 286
South Korea	599	3 585	518	3 410	388	3 954
Netherlands	1 300	9 640	1 997	15 945	366	1 751
Chile	—	—	—	—	378	1 628
Other countries	407	3 259	55	372	1 027	5 233
Total	6 225	39 603	8 310	51 487	6 475	48 220
2613.90	Molybdenum ores and concentrates, n.e.s.					
Chile	390	2 465	1 500	9 849	1 430	7 457
Netherlands	—	—	—	—	606	2 930
United States	339	1 265	—	—	103	1 096
Other countries	88	633	109	433	243	1 320
Total	817	4 365	1 609	10 285	2 383	12 805
2825.70	Molybdenum oxides and hydroxides					
India	—	—	—	—	13	169
Brazil	—	—	—	—	33	129
Other countries	96	396	58	283	—	—
Total	96	396	58	283	45	299
2841.70	Metallic molybdates					
United States	—	—	17	9	—	—
Total	—	—	17	9	—	—
7202.70	Ferromolybdenum					
United States	15	81	—	—	121	1 063
Philippines	...	2	—	—	...	1
Total	16	84	—	—	121	1065
8102.10	Molybdenum powders					
United States	...	6	...	16	...	30
South Korea	—	—	...	...	...	1
Australia	...	...	—	—	—	—
Total	...	7	...	17	...	31
8102.91	Molybdenum, unwrought, including bars or rods simply sintered; waste and scrap					
United States	12	39	1	14	12	195
Total	12	39	1	14	12	195
8102.93	Molybdenum wire					
India	—	—	...	44	...	28
Total	—	—	...	44	...	28

TABLE 1 (cont'd)

Item No.	1992		1993		1994p	
	(tonnes)	(\$000)	(tonnes)	(\$000)	(tonnes)	(\$000)
<b>EXPORTS (cont'd)</b>						
8102.99	Molybdenum and articles thereof, n.e.s.					
	United States	...	6	...	2	4 101
	Total	...	6	...	2	4 101
<b>IMPORTS<sup>2</sup></b>						
2613.10	Molybdenum ores and concentrates, roasted					
	United States	405	2 574	363	2 125	689 5 166
	Belgium	-	-	437	2 373	378 2 620
	Chile	24	158	20	113	246 2 202
	United Kingdom	-	-	-	-	20 188
	China, People's Republic of	-	-	-	-	19 91
	Other countries	58	370	...	...	- -
	Total	488	3 105	821	4 613	1 353 10 268
2613.90	Molybdenum ores and concentrates, n.e.s.					
	United States	19	182	16	158	444 3 752
	Sweden	-	-	-	-	5 38
	Germany	-	-	-	-	... 3
	Total	19	182	16	158	449 3 793
2825.70.10	Molybdenum oxides					
	United States	236	1 479	178	1 492	480 4 820
	Chile	-	-	-	-	12 113
	China, People's Republic of	-	-	-	-	11 88
	United Kingdom	...	...	-	-	- -
	Total	236	1 479	178	1 492	502 5 022
2825.70.20	Molybdenum hydroxides					
	United States	13	97	23	165	... 2
	Total	13	97	23	165	... 2
2841.70	Metallic molybdates					
	United States	527	2 849	532	3 049	461 2 923
	Germany	-	-	-	-	... 2
	Other countries	...	...	...	...	... -
	Total	527	2 850	532	3 050	462 2 926
7202.70	Ferromolybdenum					
	Chile	267	1 468	443	2 578	528 4 197
	United States	142	1 094	101	731	189 1 687
	Belgium	-	-	86	532	130 888
	United Kingdom	67	481	22	149	39 393
	France	...	2	-	-	... 3
	Other countries	17	98	47	312	- -
	Total	493	3 146	699	4 304	886 7 169
8102.10.10	Molybdenum powders, not alloyed					
	United States	3	96	2	83	6 243
	Germany	-	-	...	3	... 5
	Total	3	96	2	87	6 248
8102.10.20	Molybdenum powders, alloyed					
	United States	2	67	4	180	2 100
	Germany	...	6	-	-	- -
	Total	2	74	4	180	2 100

TABLE 1 (cont'd)

Item No.	1992		1993		1994 <sup>p</sup>	
	(tonnes)	(\$000)	(tonnes)	(\$000)	(tonnes)	(\$000)
<b>IMPORTS (cont'd)</b>						
8102.91.10	Unwrought molybdenum, not alloyed					
	Belgium	-	26	170	-	-
	United States	2	...	2	...	8
	Total	2	26	173	...	8
8102.91.20.10	Unwrought molybdenum, alloyed					
	United States	...	...	3	1	34
	Total	...	...	3	1	34
8102.91.20.20	Waste and scrap					
	United States	1	7	111	22	498
	Total	1	7	111	22	498
8102.92	Molybdenum profiles, plate, sheet, strip or foil, including bars and rods simply sintered					
	United States	8	10	500	11	572
	France	-	-	-	...	...
	Total	8	10	500	11	572
8102.93.10	Molybdenum wire, not coated or covered					
	United States	6	3	127	2	72
	Belgium	1	1	66	1	43
	Other countries	1	1	48	-	-
	Total	8	5	243	3	116
8102.93.20	Molybdenum wire, coated or covered					
	United States	4	3	105	4	109
	Belgium	...	...	8	-	-
	Austria	...	...	7	-	-
	Total	5	4	120	4	109
8102.99	Molybdenum and articles thereof, other					
	United States	13	7	319	18	821
	Austria	...	...	12	...	6
	Australia	-	-	-	...	3
	Switzerland	-	-	-	...	1
	Other countries	-	-	-	...	...
	Total	13	7	331	19	834
		<b>1992</b>	<b>1993<sup>p</sup></b>			
		(kilograms)				
<b>CONSUMPTION<sup>3</sup> (Mo content)</b>						
	Carbon steel	450 243	605 056			
	Stainless steel	121 318	251 443			
	Other steel	723 209	707 070			
	Cast iron	182 416	120 385			
	Other uses <sup>4</sup>	57 755	65 941			
	Total	1 534 941	1 749 895			

Sources: Natural Resources Canada; Statistics Canada.

- Nil; ... Amount too small to be expressed; n.e.s. Not elsewhere specified; <sup>p</sup> Preliminary.

1 Producers' shipments (Mo content of molybdenum concentrates, molybdic oxide and ferromolybdenum). 2 Imports from "Other countries" may include re-imports from Canada. 3 Available data, as reported by consumers. 4 Nonferrous alloys, electrical, pigments and other uses.

Note: Numbers may not add to totals due to rounding.

**TABLE 2. CANADA, MOLYBDENUM PRODUCTION, TRADE AND CONSUMPTION, 1975, 1980, AND 1985-94**

	Production <sup>1</sup>	Exports <sup>2</sup>	Imports		Consumption <sup>8</sup>
		Molybdenum Ores and Concentrates, Oxides and Hydroxides <sup>3</sup>	Molybdic Oxides and Hydroxides <sup>4,5</sup>	Ferro-molybdenum <sup>6,7</sup>	
(kilograms)					
1975	13 323 144	15 710 300	56 400	269 281	1 436 883
1980	11 889 000	14 584 500	361 700	53 618	1 055 107
1985	7 852 060	5 637 000	187 000	274 076	772 301
1986	11 250 625	11 367 000	203 000	347 784	684 043
1987	14 771 252	14 253 000	193 000	233 335	969 993
1988 <sup>a</sup>	13 535 186	14 026 855	187 691	345 664	1 213 248 <sup>r</sup>
1989	13 542 984	16 131 760	123 706	1 150 138	1 382 505
1990	12 188 487	11 086 429	176 481	581 782	1 179 374
1991	11 436 809	10 305 832	304 869	544 300	1 643 170
1992	8 870 267	7 138 674	249 767	493 260	1 534 941
1993	10 250 004	9 977 571	200 190	699 141	1 749 895
1994 <sup>p</sup>	9 723 278	8 903 361	502 529	886 303	..

Sources: Natural Resources Canada; Statistics Canada; except where noted.

.. Not available; p Preliminary; r Revised.

<sup>a</sup> Beginning in 1988, exports and imports are based on the Harmonized System and may not be in complete accordance with previous method of reporting.

<sup>1</sup> Producers' shipments (Mo content of molybdenum concentrates, oxide and ferromolybdenum). <sup>2</sup> Exports include H.S. classes 2613.10, 2613.90 and 2825.70. <sup>3</sup> Mo content, oxides, ores and concentrates. <sup>4</sup> Molybdic oxide includes H.S. classes 2825.70.10 and 2825.70.20. <sup>5</sup> Gross weight. <sup>6</sup> Ferromolybdenum includes H.S. class 7202.70. <sup>7</sup> For the years 1975-80, U.S. exports to Canada are reported by the U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 410), over 50% molybdenum, and for 1985-94 by Statistics Canada.

<sup>8</sup> Mo content of molybdenum products reported by consumers.