Molybdenum supply forecasting

A new plant is pictured at the right, at Cuajone Mine in southern Peru. At the end of the project, it will allow the mine to capture 95 percent of all emissions.

The dramatic increase in molybdenum prices from the low of less than $2.50/lb in 1999 to more than $40/lb in 2005 has caught the attention of molybdenum mine owners and exploration project developers. Between 2005 and early 2007, prices pulled back and stabilized within a trading range of $25/lb to $30/lb. This 1,000 percent price increase has motivated most existing producers to expand production and is motivating those with molybdenum prospects to accelerate the development process for earliest possible production. It is still unknown how much new production will come from existing mines, how much production will be needed from new mines if demand continues to grow and how many potential new mines might be available to meet future demand.

And of course, the billion dollar question is whether molybdenum prices will remain high, or will they fall back to the low levels seen during the 1980s and 1990s? This article attempts to answer these questions in a way that will help molybdenum project developers and financiers plan for the future.

There are some unique characteristics of molybdenum markets that must be understood before looking at molybdenum production, demand and price data.

Byproduct producers

About 55 percent of current molybdenum supplies are generated as a byproduct of copper mining. Many of the large copper mines around the world have small percentages, typically 0.02 to 0.03 percent, of molybdenum in the ore. It is relatively simple and cheap to recover the molybdenum. This means that a large portion of molybdenum supply comes from very low cost producers.

During periods of low or declining demand, byproduct producers have been in control of prices. Primary producers have found it difficult to compete in such times since market prices are at or below their marginal cost of production (cash costs). It should be recognized that many of the new copper mines expected to be in production in the next few years will be producing copper from oxide ores using the low cost solvent extraction/electrowinning (SX/EW) process. Mines using this process do not recover molybdenum. So, even though recent high copper prices have encouraged expansion at existing mines and the opening of new copper mines, a proportionate increase in byproduct molybdenum production is not likely.

Low price elasticity

The molybdenum market has shown very low price elasticity in recent years. With the 2004 to 2007 price increases, there has not been a significant reduction in demand. This

Rex E. Loesby

Rex E. Loesby, member SME, is president, Western Troy Capital Resources, 6164 S. Newport St., Centennial CO 80111, e-mail rexloesby@aol.com.

is partially because about 80 percent of molybdenum production is used as an alloying additive in steel. Typical molybdenum steel may have only a quarter or one-half percent molybdenum.

So, even though molybdenum prices are high, these high prices do not translate into a substantial impact on the price of the steel to the consumer. Some consumers in this market have expressed the opinion that large changes in price cause more stress than the actual price level. Steel makers must bid jobs for future delivery. If the price of molybdenum increases dramatically between the bid date and the production date, the steel maker may be required to absorb the difference. Prices of alternative alloying agents have also increased, but molybdenum is the only element that is suitable for a substantial number of applications.

No futures market

There is currently no futures market for molybdenum. The prices seen in periodicals are based on actual sales for the prior week. There are a few molybdenum traders around the world that will inventory the metal, so this gives the market some stability.

When commodity futures are available, current prices tend to be influenced by the expectations for future supply and demand. There tends to be some buff-

Table 1

Existing molybdenum producers.

Property	Company	Country	Tonnes reserves	Grade % Mo	Grade % Cu	Molybdenum Equiv. Grade
Byproduct Producers						
Sierrita	Phelps Dodge	US - Arizona	1,062,000,000	0.030%	0.260%	0.069%
Bagdad	Phelps Dodge	US - Arizona	619,000,000	0.020%	0.350%	0.073%
Chino	Phelps Dodge	US - New Mex.	72,600,000	0.020%	0.700%	0.125%
Cerro Verde	Phelps Dodge	Peru	1,392,000,000	0.020%	0.490%	0.094%
Toquepala	Grupo Mexico (SCC)	Peru	2,174,000,000	0.032%	0.731%	0.142%
Cuajone	Grupo Mexico (SCC)	Peru	1,935,000,000	0.019%	0.636%	0.114%
La Caridad	Grupo Mexico (SCC)	Mexico	480,000,000	0.028%	0.400%	0.088%
Cananea	Grupo Mexico (SCC)	Mexico	480,500,000	0.028%	0.572%	0.114%
Mission	Grupo Mexico (Asarco)	US - Arizona				
Bingham	Kennecott Rio Tinto	US - Utah	641,000,000	0.047%	0.530%	0.127%
Chuquicamata, etc.	Codelco Chile	Chile				
Los Pelambres	Antofagasta PLC	Chile	1,487,000,000	0.018%	0.660%	0.117%
Highland Valley	Teck Cominco	Canada - BC	318,000,000	0.008%	0.430%	0.073%
Antimina	Anglo/Xstrata/ Teck/BHP	Peru	450,000,000	0.031%	1.180%	0.208%
Collahuasi	Anglo/Xstrata	Chile	1,800,000,000	N/A	0.900%	
Continental Pit	Montana Resources	US - Montana	364,000,000	0.027%	0.340%	0.078%
Agarak/Zangezur	Adarak/Zangezur	Armenia				
Erdenet	Erdenet Mining Corp.	Mongolia	1,300,000,000	0.013%	0.460%	0.082%
Gibralter	Taseko	Canada - BC	194,000,000	0.100%	0.310%	0.147%
Robinson	Quadra	US - Nevada	146,000,000	0.030%	0.690%	0.134%
Mineral Park	Mercator Minerals	US - Arizona	437,000,000	0.040%	0.374%	0.096%
Huckleberry	Imperial Metals	Canada - BC		0.014%	0.552%	0.097%
Shorskoye	Celtic Resources Holdings	Kazakhstan	20,000,000	0.970%	0.057%	0.979%
Total/average			**13,572,100,000**			**0.110%**
Primary producers (surface)						
Ruyang/Luanchuan/ Huludau	Jinduicheng Molybdenum	China	900,000,000	0.100%		0.100%
Thompson Creek	Blue Pearl Mining	US - Idaho	64,500,000	0.119%		0.119%
Endako	Blue Pearl Mining	Canada - BC	74,000,000	0.063%		0.063%
Almalyk	Almalyk	Uzbekistan				
Sarcheshmeh	National Iranian Copper	Iran				
Zhirekensky + Kyrgyzstan		Russia Kyrgyzstan				
Total/average			**1,038,500,000**			**0.099%**
Primary producers (underground)						
Henderson	Phelps Dodge	US - Colorado	151,000,000	0.210%		0.210%
Questa	Molycorp (Chevron)	US - New Mexico	125,000,000	0.330%		0.330%
Ashdown Mine	Golden Phoenix	US - Nevada	132,000	2.900%		2.900%
Total/average			**276,132,000**			**0.266%**

ering of short-term supply shortages or surpluses and commodity markets are more efficient. Molybdenum prices have been somewhat more volatile and markets less efficient than copper markets, for example. This may change soon as there is the possibility of a London Metal Exchange (LME) OTC molybdenum market toward the end of 2007.

Mo vs. MoS_2

MoS_2 grades are quoted by some producers and project developers. In fact, some Chinese production figures are quoted in tonnes of MoS_2. Mo is 60 percent by weight of pure MoS_2 (Atomic weights: Mo - 95.94, S - 32.06). Also be aware that the price quoted in magazines or newspapers is usually molybdenum oxide. The quoted price is

Table 2

Potential new molybdenum producers.

Property	Company	Country	Tonnes reserves	Grade % Mo	Grade % Cu	Molybdenum Equiv. Grade
Potential future byproduct mines						
Agua Rica	Northern Orion	Argentina	731,000,000	0.033%	0.500%	0.108%
Bahuerachi	Tyler Resources	Mexico	135,000,000	0.009%	0.490%	0.083%
Berg	Terrane Metals Corp.	Canada - BC	238,000,000	0.031%	0.400%	0.091%
Costancia	Norsemont Mining	Peru	153,000,000	0.014%	0.570%	0.100%
El Pachon	Xstrata	Argentina	723,000,000	0.020%	0.650%	0.118%
Esparanza	Antofagasta PLC	Chile	786,000,000	0.012%	0.530%	0.092%
Galeno	Northern Peru Copper	Peru	765,000,000	0.014%	0.490%	0.088%
Ikiztepe/Demirkoy	Anatolia Mineral Development	Turkey	200,000,000	0.050%	0.410%	0.112%
MacLeod Lake	Western Troy	Canada - QC	27,500,000	0.073%	0.500%	0.148%
Los Chancas	Southern Copper	Peru	200,000,000	0.070%	1.000%	0.220%
Los Verdes	Virgin Metals	Mexico	10,500,000	0.124%	0.460%	0.193%
Magistral	Inca Pacific Resources	Peru	189,000,000	0.052%	0.510%	0.129%
Northern Dancer*	Largo Resources Ltd.	Canada - BC	164,000,000	0.031%	0.103%	0.083%
Pashpap	Northern Peru Copper	Peru	101,000,000	0.049%	0.350%	0.102%
Pebble	Northern Dynasty	US - Alaska	2,323,000,000	0.033%	0.580%	0.120%
Petaquilla	Tech, Inmet, Petaquilla	Panama	1,115,000,000	0.015%	0.500%	0.090%
Quellaveco	Anglo American Peru		761,000,000	0.023%	0.570%	0.109%
Red Bird	Torch River Resources	Canada - BC	81,500,000	0.065%	0.070%	0.076%
Relincho	Global Copper Corp.	Chile	184,000,000	0.024%	0.590%	0.113%
Rio Blanco	Monterrico Metals	Peru	1,257,000,000	0.023%	0.570%	0.108%
Rosemont	Augusta Resource	US - Arizona	398,000,000	0.016%	0.550%	0.099%
Sierra Gorda	Quadra Mining	Chile	215,000,000	0.066%	0.380%	0.123%
Spinefex	Moly Mines	Australia	470,000,000	0.060%	0.090%	0.074%
Toromocho	Peru Copper	Peru	1,200,000,000	0.019%	0.528%	0.098%
Vizcachitas	GHG Resources Chile		144,000,000	0.015%	0.510%	0.092%
Total/average			**12,571,500,000**			**0.106%**
Potential future primary surface mines						
Ajax	Tenajon Resources	Canada - BC	345,000,000	0.070%		0.070%
Bald Butte	United Bolero	Canada - BC	149,000,000	0.060%		0.060%
Bugdainsky	Norilsk	Russia				
Climax	Phelps Dodge	US - Colorado	87,000,000	0.250%		0.250%
Creston		Mexico	112,600,000	0.091%		0.091%
Malmbjerg	International Molybdenum	Greenland	217,000,000	0.134%		0.134%
Mt. Hope	Idaho General	US - Nevada	1,000,000,000	0.110%		0.110%
Lucky Ship	New Cantech Ventures	Canada - BC	29,100,000	0.090%		0.090%
Ruby Creek	Adanac Moly Corp.	Canada - BC	206,375,000	0.063%		0.063%
Storie	Columbia Yukon	Canada - BC	100,500,000	0.077%		0.077%
Total/average			**2,246,575,000**			**0.101%**
Potential future primary underground mines						
Davidson	Blue Pearl Mining	Canada - BC	75,500,000	0.177%		0.177%
Kingsgate	Auzex	Australia	5,000,000	0.300%		0.300%
MAX (Trout Lake)	Roca Mines Inc.	Canada - BC	43,000,000	0.133%		0.133%
Red Mountain	Tintina Mines Ltd.	Canada - Yukon	187,000,000	0.160%		0.160%
Total/Average			**310,500,000**			**0.163%**

* Primary mineral is tungsten.

FIGURE 1

Molybdenum prices per pound between 1950 and 2006 in 2006 U.S. dollars.

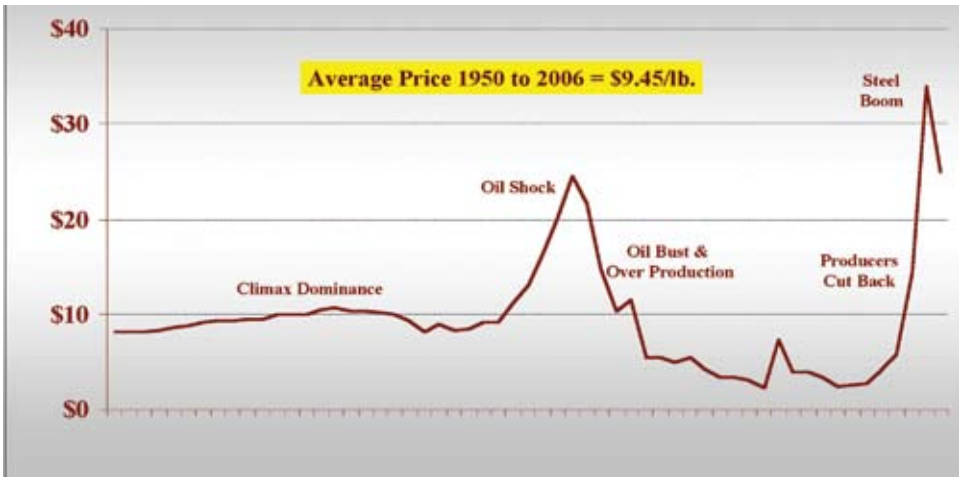


FIGURE 2

World molybdenum production (USGS).

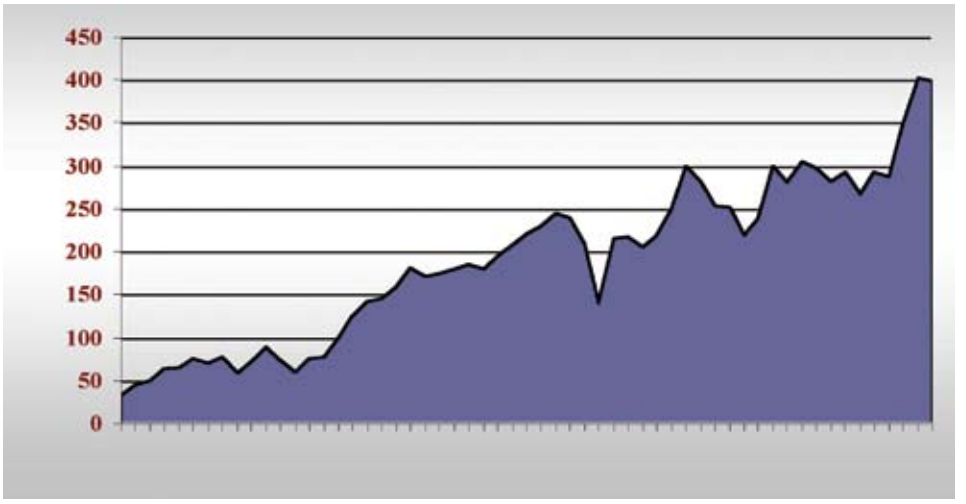
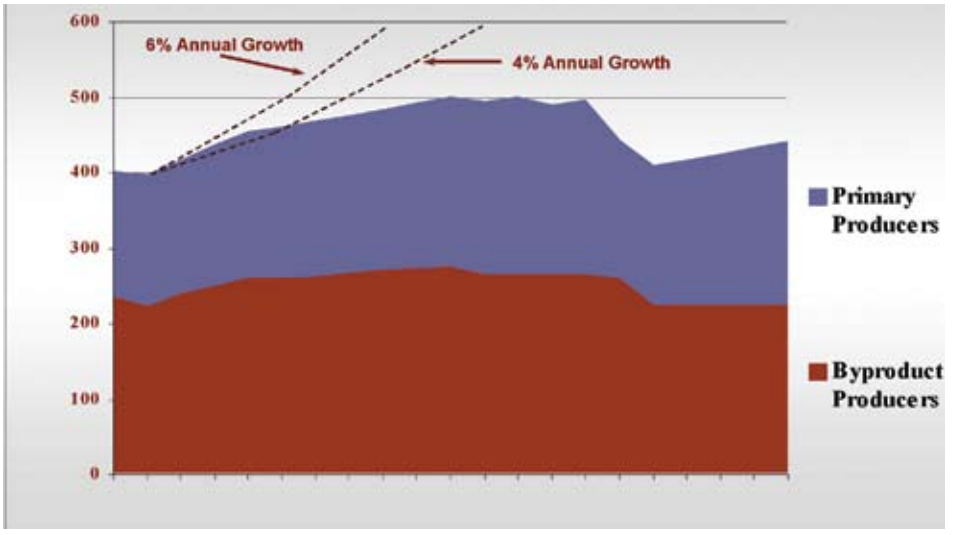


FIGURE 3

Existing mine production forecast.



only for the contained Mo by weight. This article uses pounds of Mo for price and production statistics.

Historical data

The best source of free historical information on most commodities is the Minerals Information Team of the U.S. Geologic Survey (USGS). World molybdenum production and price data is collected and updated monthly, and data is available going back to early in the 20th century.

Figure 1 shows the molybdenum price between 1950 and 2006 in constant 2006 U.S. dollars. The Consumer Price Index was used to adjust real prices to 2006 dollars. The following section will look at some major time frames to see what may have influenced prices during those times.

1950 to 1980 — Climax Molybdenum dominated markets until about 1980. The Climax Mine in Leadville, CO produced about 50 percent of the world supply during this period. In 1976, the Henderson Mine, also owned by Climax, began producing and reached full production in 1981.

Prices were stable until the late 1980s as Climax based its pricing primarily on the cost of production at the Climax Mine. Prices rose above the stable trend in 1977 primarily in response a supply shortage and the belief at the time that demand would continue to increase at about 7 percent per year as it had during the period between 1962 and 1976.

The oil boom of 1979 gave a boost to molybdenum demand as steelmakers were asked to produce large amounts of molybdenum steel for drilling and pipelines. The supply shortage encouraged copper producers to add molybdenum circuits and new primary mines opened. The boom did not last and there was a glut of drilling rigs for many years following the boom, causing low demand for molybdenum from that market segment.

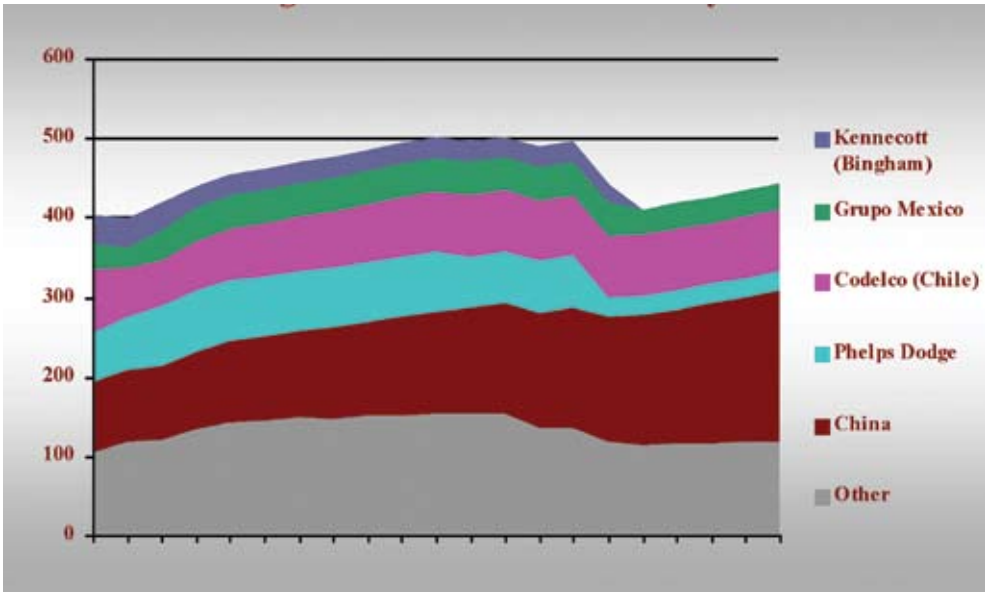
1986 to 2001 — The high prices of 1977 to 1983 encouraged new production from both primary and byproduct mines and demand fell to levels in 1986, when byproduct producers dominated the market. The Climax Mine ceased production and was put on "care and maintenance" in 1986.

Because byproduct producers' costs were so low, molybdenum prices fell to levels well below the historical average of about $10/lb (2006 dollars). During this period, Cyprus Minerals purchased Amax (parent of Climax Molybdenum). So Cyprus then controlled the Climax and Henderson mines.

The Climax Mine was reopened for a short period in 1995 during a period of price strength. In 1999, Phelps Dodge bought Cyprus. Phelps Dodge had a number of byproduct producing mines in Arizona and New Mexico. It recognized that high production of molybdenum was hurting the market. So in 2001, Phelps Dodge reduced production of molybdenum (along with reductions in copper production) at most of its mines, hoping to see higher prices. Kennecott and Chile's Codelco also reduced production of molybdenum.

FIGURE 4

Existing mine production forecast by source.



2004 to 2007 — A world boom in steel production occurred in 2004 and 2005. Chinese steel production increased, the demand for pipeline steel and drill steel was strong and the use of molybdenum in the production of low-sulfer diesel fuel has been expanding. These effects on the demand side, along with production cutbacks and constraints in molybdenum refining (roaster) capacity, sent the price of molybdenum to more than $40/lb in mid-2005. Late in 2005, it was thought the high prices could not last as additional roaster capacity came onstream and production increased. The expectation was that prices would pull back and average about $15/lb in 2006. This did not happened and prices were steady at the $25/lb level throughout most of 2006 and into 2007.

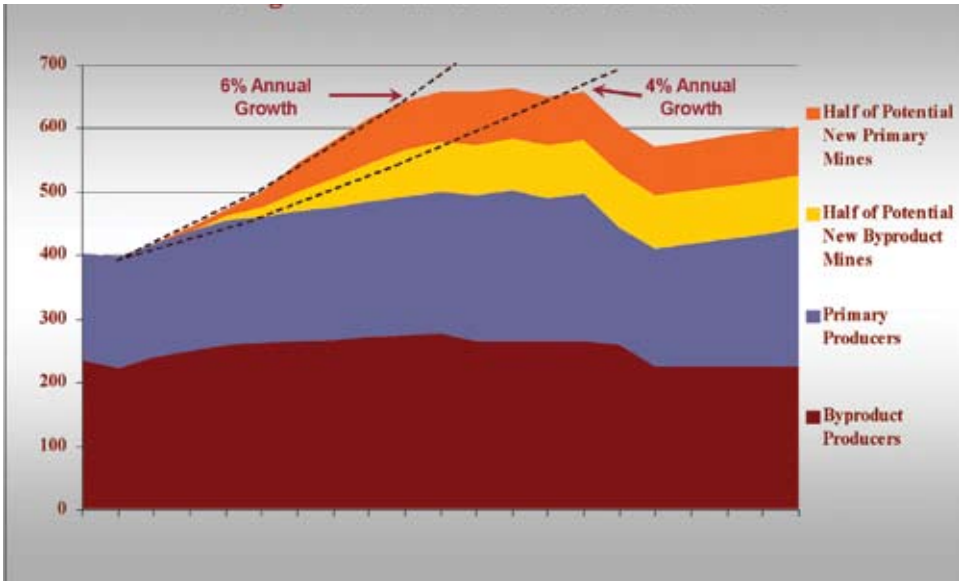
There have recently been production problems in Chile, Mexico and China that were not foreseen. At Chuquicamata in Chile, the main conveyor was damaged by a rock slide. In Mexico, there were a number of strikes. In China, a number of small mines were temporarily closed due to environmental and safety issues. So there has actually been a slight reduction in overall supply in 2006, compared with 2005, thus keeping supplies short and prices stable.

Figure 2 shows molybdenum production during the same period as the price chart. USGS data was used through 2004. The USGS estimates for 2005 and 2006 have been adjusted slightly by the author to reflect data gathered on a mine by mine basis. Molybdenum consumption for each year varies a bit from production, but not enough to be significant when looking at long-term trends.

If just the 1990 to 2006 period is considered, it would look like there has been a huge increase and breakout from a trading range of around 300 million lbs/year. But a look at the trend since 1950 shows that the recent growth

FIGURE 5

Growth curves for future demand.



has not broken out of the long-term trend of about 4 percent growth per year. Of course, the 4 percent average growth rate has not been smooth. Between 1963 and 1981, a period of almost 20 years, the growth rate averaged 7.7 percent. From 1981 to 1983, there was a 42-percent drop. From 1989 to 1993 there was a 27-percent drop. And, from 2003 to 2005 there was a 30-percent increase.

Supply and demand forecast

Figure 3 is a forecast for production or announced production expansion at existing mines for the next 20 years. No new mines are included in the forecast. Table 2 is a tabulation of the mines included. The data was gathered from several public sources including 10k's, annual reports, company Web sites, mining data Web sites USGS data and industry periodicals. As a check, the total production defined in such reports for 2005 was compared with the total world production reported by the USGS. A total of 402 million lbs was found versus 408 million lbs reported by the USGS.

It should be recognized that published forecasts of current reserves or mine life are typically not an accurate reflection of the future production from a mine. More often, mine life is extended through improvements in mining methods, the discovery of new ore zones, or both. For example, Thompson Creek is redesigning the openpit based on a projected life of mine molybdenum price of $10/lb. Previous planning used a price of $5/lb. This will

Table 3

Forecast of existing molybdenum mine production (millions of pounds of Mo).

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Byproduct producers												
Sierrita	19	20	20	20	20	20	20	20	20	20	20	20
Bagdad	11	10	10	10	10	10	10	10	10	10	10	
Chino	1	1	2	2	2							
Cerro Verde	0	0	3	4	4	4	4	4	4	4	4	4
Toquepala	12	13	12	12	12	12	12	12	12	12	12	12
Cuajone	12	8	12	12	12	12	12	12	12	12	12	12
La Caridad	9	6	9	9	9	9	9	9	9	9	9	9
Cananea			6	9	9	9	9	9	9	9	9	9
Mission			0	0	0	0	0	0	0	0	0	0
Bingham	34	37	34	27	27	27	27	27	27	27	27	27
Codelco	81	60	57	63	65	67	69	70	73	75	77	77
Los Pelambres	19	22	24	24	24	24	24	24	24	24	24	24
Highland Valley	6	4	4	4	4	4	4	4	4	4	4	4
Antamina	15	17	18	18	18	18	18	18	18	18	18	18
Collahuasi	1	7	8	10	12	13	14	15	16	17	17	17
Continental Pit	6	6	7	8	9	9	9	9	10	10	10	10
Agarak/Zangezur	6	6	6	6	6	6	6	6	6	6	6	6
Erdenet	3	3	3	3	3	3	3	3	3	3	3	3
Gibralter	0	1	1	1	1	1	1	1	1	1	1	1
Robinson	0	0	0	0	1	1	1	1	1	1	1	
Mineral Park	0	0	0	4	8	8	8	8	8	8	8	8
Huckleberry	1	0	1									
Shorskoye	1	1	1	2	3	3	3	3	3	3	3	3
Subtotal	**235**	**223**	**239**	**250**	**260**	**261**	**264**	**267**	**271**	**274**	**276**	**265**
Primary producers (surface)												
Ruyang/Luanchuan/Hu	88	90	94	98	102	106	110	114	119	124	129	134
Thompson Creek	19	17	13	17	18	18	18	18	18	18	18	18
Endako	10	12	11	13	13	13	15	15	15	15	15	15
Almalyk	1	1	1	1	1	1	1	1	1	1	2	2
Sarcheshmeh	4	5	5	5	5	5	6	6	6	6	7	7
Zhirekensky +	7	7	7	7	7	7	8	8	8	9	9	9
Kyrgystan	1	1	1	1	1	1	1	1	1	1	1	1
Subtotal	**130**	**132**	**131**	**142**	**147**	**151**	**158**	**163**	**169**	**174**	**180**	**185**
Primary producers (underground)												
Henderson	32	37	40	40	40	40	40	40	40	40	40	40
Questa	5	5	5	5	5	5	5	5	5	5	5	5
Ashdown Mine	0	1	2	2	2	2	2					
Subtotal	**37**	**43**	**47**	**47**	**47**	**47**	**47**	**45**	**45**	**45**	**45**	**45**
Total existing mines	**402**	**399**	**418**	**439**	**454**	**460**	**470**	**475**	**484**	**493**	**501**	**495**

allow higher strip ratios and the inclusion of lower grade ores that would have previously been considered waste. Many producers have published such plans and they have been included in the forecast for future production and mine life used in Fig. 3. Where there is no production forecast or reliable reserve published by a particular source, such as China or other countries where reserve reports are not available, the author assumed there would be a 4-percent annual growth in production.

One of the conclusions one might draw from Fig. 3 is that demand would need to drop by 40 percent or so to reach a level where byproduct producers will again be dominant in setting prices. Another conclusion is that if demand grows by 4 percent annually, substantial production from new mines will be needed beginning in three to four years.

Figure 4 is the same chart showing the share of the market held by the major producers. Note that currently, more than 50 percent of production is generated by Phelps Dodge, Codelco, Grupo Mexico and Kennecott. Note that China produced about 23 percent of supply in 2006. Since China production and reserve data is unavailable or unreliable at best, the overall reliability of the forecast suffers.

Molybdenum demand

It is beyond the scope of this article and the expertise of the author to look into the details of all the market segments of molybdenum consumption to develop a forecast of molybdenum demand growth. However, after reading a number of articles on the subject, it seems that even authors who have expertise in molybdenum market segment consumption tend to fall back to a conclusion for overall demand that is based on the historical growth rate of approximately 4 percent a year. Apparently, it is next to impossible to forecast demand in many market segments because it would require information on the future plans of all steel producers around the world — information that the producers are reluctant to share as it would likely end up in the hands of competitors. A market specialist at Phelps Dodge recently forecast 2007 growth at between 4 and 5 percent.

There are indications the growth rate during the next 10 years or so may be higher than the historical average due to the potential for higher levels of world economic growth, pipeline construction demand, atomic waste storage container demand and the increased use of molybdenum in petroleum refining.

China's economy continues to expand at an 11-percent rate. China has more than 441 million st of annual steel production capacity, as much as all of North American and Europe combined, and more is planned. For years, economic pundits have forecast a burst in the China bubble, but that has not yet happened. This article will use a 4-percent overall growth forecast as a base case and then look at a 6-percent growth rate for comparison.

Potential new molybdenum production

It is evident that a substantial amount of new molybdenum production will be needed if demand grows at the historical average of 4 percent a year. What molybdenum projects are available to meet this demand? Table 1 is a list of the existing molybdenum mines. Table 2

2017	2018	2019	2020	2021	2022	2023	2024	2025
20	20	20	20	20	20	20	20	20
4	4	4	4	4	4	4	4	4
12	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12
9	9	9	9					
9	9	9	9	9	9	9	9	9
0	0	0	0	0	0	0	0	0
27	27	27	27					
77	77	77	77	77	77	77	77	77
24	24	24	24	24	24	24	24	24
4	4	4						
18	18	18	18	18	18	18	18	18
17	17	17	17	17	17	17	17	17
10	10	10	10	10	10	10	10	10
6	6	6	6	6	6	6	6	6
3	3	3	3	3	3	3	3	3
1	1	1	1	1	1	1	1	1
8	8	8	8	8	8	8	8	8
3	3	3	3	3	3	3	3	3
265	**265**	**265**	**261**	**225**	**225**	**225**	**225**	**225**
139	145	150	156	163	169	176	183	190
18								
15	15	15						
2	2	2	2	2	2	2	2	2
7	7	8	8	8	9	9	9	10
10	10	11	11	11	12	12	13	13
1	1	1	1	1	1	1	1	1
192	**180**	**186**	**178**	**185**	**193**	**201**	**209**	**217**
40	40	40						
5	5	5	5					
45	**45**	**45**	**5**	**0**	**0**	**0**	**0**	**0**
501	**490**	**496**	**444**	**410**	**418**	**425**	**433**	**442**

lists the potential new molybdenum projects the author has identified to date.

There are more than 280 known molybdenum or molybdenum byproduct exploration properties around the world. Only projects that have published measured, indicated or inferred molybdenum resources are included in Table 2. A few projects with known resources have been omitted due to perceived permitting hurdles that are likely to delay the project for many years. The resource numbers shown in Table 2 most often include only measured and indicated resources, although in a limited number of cases, inferred resources have been included.

Table 4

Potential new molybdenum mine production (millions of pounds).

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Potential future byproduct mines										
Agua Rica					8	15	15	15	15	15
Bahuerachi					1	2	3	3	3	3
Berg							2	5	5	5
Costancia						1	1	1	1	1
El Pachon										
Esparanza								5	5	5
Galeno							2	4	5	5
Ikiztepe/Demirkoy									2	4
Los Chancas					3	5	7	7	7	7
Los Verdes		1	2	2	2	2	2	2	2	2
MacLeod Lake					1	1	1	1	1	1
Magistral				2	4	6	6	6	6	6
Northern Dancer*					2	3	3	3	3	3
Pashpap						1	3	3	3	3
Pebble					0	5	10	20	20	20
Petaquilla			2	4	6	6	6	6	6	6
Quellaveco						3	5	5	5	5
Red Bird						3	5	5	5	5
Relincho					1	2	2	2	2	2
Rio Blanco						5	10	12	12	12
Rosemont			3	5	10	10	10	10	10	10
Sierra Gorda					2	4	6	6	6	6
Spinefex			8	16	16	16	16	16	16	16
Toromocho							5	10	14	14
Vizcachitas				2	2	2	2	2	2	2
Subtotal			**15**	**30**	**58**	**92**	**122**	**149**	**156**	**158**
Potential future primary surface mines										
Ajax									5	10
Bald Butte							3	6	6	6
Bugdainsky		5	10	15	15	15	15	15	15	15
Climax			3	10	20	20	20	20	20	20
Creston				6	12	12	12	12	12	12
Malmbjerg					7	15	20	20	20	20
Mt. Hope				8	17	25	35	35	35	35
Lucky Ship			1	2	2	2	2	2	2	2
Ruby Creek				2	14	14	10	11	11	9
Storie						3	5	5	5	5
Subtotal		**5**	**14**	**43**	**87**	**106**	**122**	**126**	**131**	**134**
Potential future primary underground mines										
Davidson				1	2	4	5	5	5	5
Kingsgate	2	3	3	3	3	3	3	3	3	3
MAX (Trout Lake)	0	3	3	3	3	3	3	3	3	3
Red Mountain						7	10	13	17	20
Subtotal	**2**	**6**	**6**	**7**	**8**	**17**	**21**	**24**	**28**	**31**
Total potential new production	**2**	**11**	**35**	**80**	**153**	**214**	**265**	**299**	**315**	**323**

The author has refrained from prioritizing or ranking the potential new projects other than to list the projects by type (byproduct surface, primary surface, primary underground). A copper price of $1.50/lb and a molybdenum price of $10/lb are used to calculate Mo equivalent grade ($5/lb was used for the lone tungsten project). Other factors will come into play when determining which projects may make it into production. These include reserve size, location, management capability, the availability of financing and permitting. However, when evaluating whether a particular project has relative merit, the place to start is resource quality, including grade, reserve size, location and whether the resource can be surface mined.

Tables 3 and 4 show estimated future production by year for existing mines and potential future mines based on the owners' published expectations. Since many of the potential new mines are controlled by companies that have yet to secure financing for development, these companies tend to present their projects in the most favorable light and thus publish optimistic schedules for production. The author has in most cases used the companies' forecasts for future production. But in some cases, the published production schedule has been delayed a year or two.

If prices for molybdenum remain at current levels, it can be assumed that most, if not all of the potential new mines are economic and have a good probability of coming on stream. In fact, most of the potential new mines are very likely economic at prices substantially below $15/lb. However, it should also be recognized that the process for bringing any new mine production is filled with difficult hurdles and challenges. Another factor is that the first projects to obtain financing will likely bump other large projects back at least a few years. Once a few large projects are committed, the remaining large projects will find it more difficult to secure financing.

Figure 5 adds potential new mine production to existing mine production. Rather than passing judgment on individual potential new mines, the author has chosen to account for the uncertainty of specific projects by showing half of the potential new mine production listed in Table 4. Also shown on Fig. 5 are demand growth rates of 4 and 6 percent. The growth curves for future demand shown in Fig. 5 are very smooth. The reader needs to go back and look at Fig. 2 to see that production (and consumption) has been anything but smooth. There have been decades-long periods of

2017	2018	2019	2020	2021	2022	2023	2024	2025
15	15	15	15	15	15	15	15	15
3	3	3	3	3	3	3	3	3
5	5	5	5	5	5	5	5	5
1	1	1	1	1	1	1	1	1
5	10	14	14	14	14	14	14	14
5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	5
4	4	4	4	4	4	4	4	4
7	7	7	7	7	7	7	7	7
2	2							
1	1	1	1	1	1	1	1	1
6	6	6	6	6	6	6	6	6
3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3
20	20	20	20	20	20	20	20	20
6	6	6	6	6	6	6	6	6
5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	5	5	5
2	2	2	2	2	2	2	2	2
12	12	12	12	12	12	12	12	12
10	10	10	10	10	10	10	10	10
6	6	6	6	6	6	6	6	6
16	16	16	16	16	16	16	16	16
14	14	14	14	14	14	14	14	14
2	2	2	2	2	2	2	2	2
163	**168**	**169**	**169**	**169**	**169**	**169**	**169**	**169**
10	10	10	10	10	10	10	10	10
6	6	6	6	6	6	6	6	6
15	15	15	15	15	15	15	15	15
20	20	20	20	20	20	20	20	20
12	12	12	12	12	12	12	12	12
20	20	20	20	20	20	20	20	20
33	31	31	31	31	31	31	31	31
2	2	2	2	2	2	2	2	2
9	8	7	8	9	9	9	9	6
5	5	5	5	5	5	5	5	5
132	**129**	**128**	**129**	**130**	**130**	**130**	**130**	**127**
5	5	5	5	5	5	5	5	5
3	1							
3								
20	20	20	20	20	20	20	20	20
31	**26**	**25**	**25**	**25**	**25**	**25**	**25**	**25**
325	**324**	**323**	**323**	**324**	**324**	**325**	**324**	**322**

The Cuajone Mine, shown here, was inaugurated in November 1976. It is located at the Moquegua Department. The first mine is Toquepala, developed from 1956 to 1960 when it began operations.

greater than 7 percent growth and a few large decreases in demand.

Conclusions

It is evident that molybdenum supply and demand balance may be maintained for at least a few years if demand grows at the historical average of around 4-percent per year. Existing producers should be able to meet market demand. If growth rates are higher than 4 percent, shortages will send prices higher than even the current levels of about $30/lb. So molybdenum prices may hold above $10/lb, and possibly even above $20/lb for this period. This assumes there will be no large supply increases out of China or the former Soviet Union.

It would take a drop in demand of 30 to 40 percent in order for byproduct producers to become dominant in setting molybdenum prices. So, even if oversupply conditions develop in the short term, it is unlikely prices will fall below $10/lb for the foreseeable future.

The mines in the Huludau District in China that were closed in 2005 for environmental and safety concerns are slowly coming back onstream. These mines can produce 20 to 25 million lbs/year and this production could come back more quickly than is currently thought. This is not factored into the forecast for existing mine production out of China.

At current prices, most all of the identified potential new mines will be economic and could come into production by 2015 or sooner. However, the financial community will likely not support any project that requires $25/lb molybdenum prices for the life of the potential mine. They will look favorably on projects that can make good money at prices somewhere near the historical average of about $10/lb and have cash costs substantially below $10/lb so they can survive the inevitable periods of oversupply.

There is a race among the junior molybdenum companies to see who can get financed first. Once a few large projects are financed, the supply of molybdenum might be able to meet demand and securing financing for the larger potential primary molybdenum mines will be more difficult. Of course, potential byproduct mines may have less difficulty in securing financing as there will be less molybdenum price risk. Also, those projects that are controlled by large mining companies will have less difficulty in securing financing.

The potential new sources to watch are the Climax Mine in Colorado, Mt. Hope in Nevada, Bugdainsky in Russia and Spinefex in Australia. These are all large potential producers that could come onstream between 2009 and 2011. If all four of these mines come onstream, along with a number of the byproduct and smaller projects, and demand does not grow at a rate above four percent, an oversupply condition will develop between 2010 and 2017.

A good case can be made for the view that, because of high economic growth rates in China, India and other third world countries, we may be experiencing a quantum shift in world economic growth. Thus, the conventional assumption that molybdenum demand will grow at only the historic average of four percent may be low. We may be in the beginning of one of the long periods of much higher than average growth rates that molybdenum markets have experienced. So a growth rate of 6 percent or higher is not out of the question during the next 10 to 20 years. Figure 5 shows that if demand grows at 6 percent, and only half of potential new mines come in on schedule, there will not be enough molybdenum supply to satisfy demand.

After 2020, all bets are off. If, as in the past, one of the 30 to 40 percent decreases in demand occurs, molybdenum prices below $5/lb are a real possibility. On the other hand, if we experience even the average of 4 percent growth in demand, it is unlikely known sources will produce enough molybdenum to meet growing demand and prices are likely to remain above $20/lb for many years. ■