MOLYBDENUM MARKET OVERVIEW

1.0 INTRODUCTION

Molybdenum is a metallic element, which is most frequently used as an alloying addition in alloy and stainless steels. Its alloying versatility is unmatched because its addition enhances strength, hardenability, weldability, toughness, elevated temperature strength and corrosion resistance.

Although molybdenum is primarily used in steel production, its complex and unique properties are proving invaluable in an expanding a range of alternative alloy systems and chemicals.

One of the unique features of molybdenum, as distinct from other heavy metals, is that laboratory tests have shown its compounds to be of low toxicity. This provides opportunities for increased applications in areas such as chemicals and oxidation catalysts.

Although steels and cast iron comprise the single biggest market segment, molybdenum's diversity has also proven invaluable in superalloys, nickel base alloys, lubricants, chemicals, electronics and many other applications.

2.0 RESOURCES AND SUPPLY

Molybdenum occurs as the principle metal sulphide in large low-grade porphyry molybdenum deposits and as associated metal sulphide in low-grade porphyry copper deposits. In most cases, the value of these deposits is determined by the commercial availability of the alternative products such as copper, although in USA, there are a number of deposits that are mined solely for the production of molybdenum.

Globally, identified resources amount to about 19 million tonnes with China having the largest with an estimated 8.3 million tonnes followed by USA and Chile.

Molybdenum is only known to occur in a natural state chemically combined with other elements. Although a number of molybdenum-bearing minerals have been identified, the only one of commercial significance is molybdenite (MoS_2) - a natural molybdenum sulphide. In ore bodies, molybdenite is generally present in quantities from 0.01- 0.50 per cent and is often associated with the sulphide minerals of other metals, notably copper.

Ore bodies and mines can be classified in three types:

- Primary mines, where the recovery of molybdenite is the sole objective;
- By-product mines, which remove molybdenite during copper recovery;
- Co-product mines, where commercial viability is dependent upon the extraction of both molybdenite and copper-bearing minerals.

2.1 Mining and Processing

2.1.1 Mining

The relatively low grade of most Mo ores necessitates the use of high volume low cost mining extraction techniques, most commonly:

- Massive open cast pits; or
- Underground block caving, wherein large blocks of ore are undercut and allowed to collapse under their own weight.

2.1.2 Milling

Mined ore is generally pulverised through a series of crushing and ball and/or rod mills to micronised particles. The fineness is necessary to assist in the liberation of the molybdenite from the host ore. A water slurry of the ore is then conditioned with agents – including some fuel or diesel oil – which coats the molybdenite particles, rendering them water-repellent (hydrophobic).

Separation by flotation takes place in aerated tanks. This is usually a continuous process with subsequent regrinding and reflotation stages to improve recovery. The final concentrate contains between 70-90 per cent molybdenite. If required, an acid leach may be employed to dissolve impurities such as copper and lead.

2.1.3 Roasting

The roasting process converts molybdenite concentrate into technical molybdenum oxide by the following chemical reactions. These take place at 600-700C in large multihearth furnaces or 'roasters'. Sulphide concentrate is rabbled from the centre to the periphery of one hearth where it drops to the hearth below and is rabbled back to the centre. It reacts continuously with a steady supply of forced air during the 10 hours it takes to complete the circuit across a dozen more hearths. The resulting technical grade molybdenum oxide typically contains a minimum of 57 per cent molybdenum, and less than 0.1 per cent sulphur. Desulphurisation systems remove sulphur dioxide from the effluent roaster gases.

2.1.4 Products

Molybdenum is basically supplied to global markets in three forms; either as roasted molybdenite concentrates (generally known as 'tech-oxide') as ferro-molybdenum or as molybdenum metal.

2.2 Production and Supply

Global production of molybdenum is basically controlled by a number of countries including Chile, USA and China. These three countries produce approximately 75 per cent of all output and are are the major influence on world markets. Peru and Canada also produce considerable quantities as a by-product of copper production. Small quantities are produced in a number of other countries including Mexico, Russia and Armenia.

2.2.1 Chile

Chile is one of the three major producing countries with production exceeding 40,000 tonnes in 2004. All production is as a result of by-production of copper operations, and primarily from the government owned Codelco with its major operation at Los Pelabres. Molymet is a privately owned processing company that purchases concentrates from the copper producers and produces ferro-molybdenum. With very limited domestic consumption, effectively all Chilean production is exported, mainly to Europe and Japan.

2.2.2 USA

Historically USA has been the largest producer of molybdenum and production peaked at 42,000 tonnes in 1999. However, over the past five years, production has started to decline, and during 2004 was estimated at 36,000 tonnes.

Molybdenum is produced in USA as both a primary product, and also as a by-product of copper production. Primary production is currently located in Colorado, New Mexico and Idaho, however a number of other operations have either been

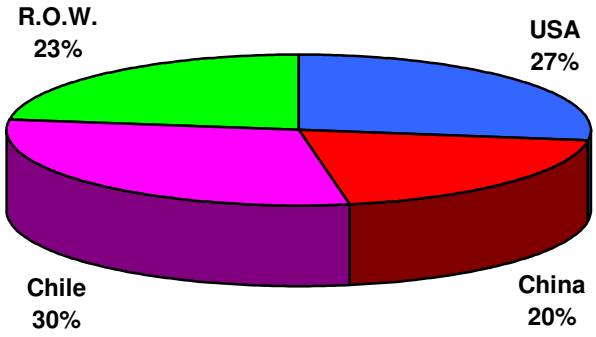
permanently closed, or placed on care and maintenance until other mines are exhausted.

2.2.3 China

With the largest known reserves, and a rapidly increasing domestic market, China has evolved over the past decade as one of the largest and most cost effective producers of molybdenum. During 2004 Chinese production of molybdenum was estimated at 27,800 tonnes (contained Mo).

Three of the six largest molybdenum mines in the world are located in China; Luanchuan in Henan province, containing reserves of 1.3 Mt; Daheishan in Jilin Province, with 1.1Mt; and Jinduicheng in Shanxi province with around 970,000 tonnes. With a significant cost advantage over western producers each of these operations is capable of increasing production to meet increasing domestic demand and for export. Figure 1 summarises global production of molybdenum in 2004.

Figure 1 – Global Production 2004



	(tonnes)
USA	37,900
Chile	41,800
China	27,800
R.O.W.	31,500
Total	**139,000**

3.0 APPLICATIONS OF MOLYBDENUM

Molybdenum is a refractory metallic element used principally as an alloying agent in steel, cast iron, and superalloys to enhance hardenability, strength, toughness, and wear and corrosion resistance. To achieve desired metallurgical properties, molybdenum, primarily in the form of molybdic oxide, or ferro-molybdenum, is frequently used in combination with or added to, chromium, columbium, 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 stress, expanded temperature ranges, and highly corrosive elements. Moreover molybdenum finds significant use as a refractory metal in numerous chemical applications, including catalysts, lubricants and pigments. The variety of uses for molybdenum metals, few of which afford acceptably substitution, has resulted in a very significant increase in demand over the last decade.

The key attributes of molybdenum are summarised as follows:

- Alloying versatility is unmatched because its addition enhances strength, hardenability, weldability and toughness.
- Hard and tough, but it is softer and more ductile than tungsten.
- Heat resistant.
- Low toxicity.
- Corrosion resistant.
- Lowest thermal expansion coefficient of the engineering metals.
- High melting temperature.

Notwithstanding these outstanding qualities, the reasonably high cost of production and high cost of fabrication has limited molybdenum's use to areas in which its properties provide a demonstrable advantage over alternative metals.

3.1.1 The Iron and Steel Industries

The iron and steel industry consumes 75 per cent of the molybdenum produced. Molybdenum is primarily used as an alloying element in steel, cast iron and non-ferrous metals. More specifically, major end-use applications of molybdenum include machinery, electrical, transportation, chemicals, and the oil and gas industries. Applications include:

- Stainless Steels
- Tool and High Speed Steels
- High Strength Low Alloy (HSLA) Steels
- Carburising Steels
- High Temperature Steels
- Cast Irons

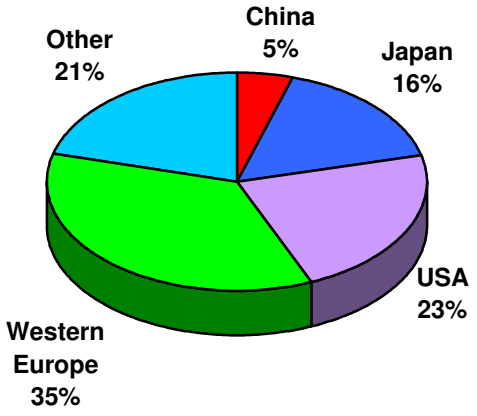
3.1.2 Non Ferrous Applications

- Chemical products
- Superalloys and Molybdenum Based Alloys
- Titanium Based Alloys

4.0 REGIONAL CONSUMPTION

Figure 2 summarises global consumption by region in 2004.

Figure 2 – 2004 Global Consumption By Region



	(Tonnes)
Western Europe	49,909
USA	31,760
Japan	22,868
China	6,805
Other	29,491
Total	**140,833**

5.0 MARKET STRUCTURE AND TRADE

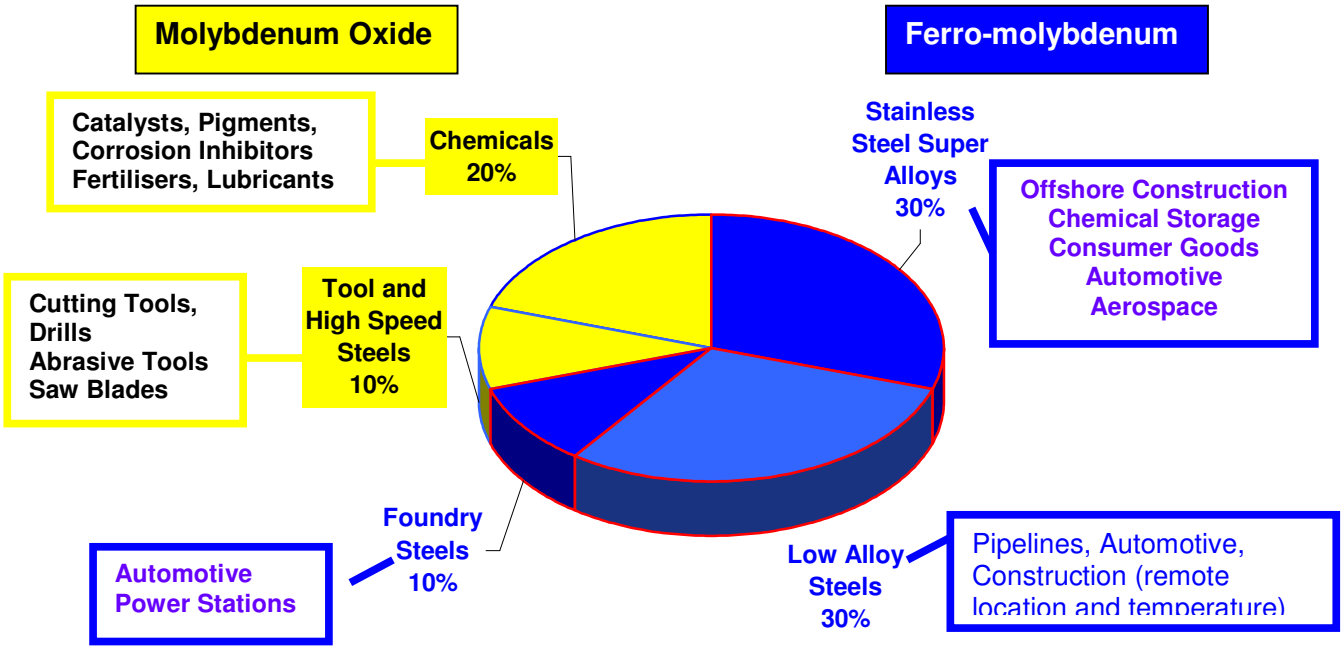
5.1 Market Structure

Molybdenum is supplied to global markets in two forms, being ferro-molybdenum which contains approximately 65 per cent Mo or as molybdenum roasted concentrates (oxide) which contains approximately 57 per cent Mo.

With a very large percentage of molybdenum being produced as either a by-product or co-product, production programs are often determined by the market requirements for the major products such as copper or tungsten.

Chile, USA and China are the three largest producers with combined production representing approximately 75 per cent of total demand. Whilst having a clear cost advantage, Chinese exports of ferro-molybdenum and molybdenum oxide have been curtailed in recent years due to anti-dumping actions in both USA and Europe. However, with a rapid increase in domestic demand, Chinese molybdenum producers continue to expand production. Figure 3 details the molybdenum structure by industry.

Figure 3 – Molybdenum Industry Structure



5.2 Forward Demand Trends

5.2.1 Factors That Will Influence Future Demand

5.2.1.1 Stainless Steels

Production of stainless steel is one of the main drivers of molybdenum demand with about 30 per cent of the volume of molybdenum used annually. The momentum of world stainless steel consumption is heavily dependent on the global economic situation and corresponding GDP growth. This can vary significantly by region, particularly with the massive growth currently occurring in China and other parts of South East Asia.

During 2004, global consumption of molybdenum in stainless steel production totalled 42,000 tonnes, representing a 6 per cent increase over the previous year. A significant percentage of this increase was in China.

The trends in molybdenum consumption in stainless steel can be summarised as:

- Stainless steel production and hence molybdenum consumption has grown consistently over the past 20 years.
- Increasing applications for stainless steel is the major driving factor.

- Despite some fairly strong variations in price during this period, growth in consumption has been largely unaffected by price variations.
- Despite strong growth in other applications such as alloys and chemicals, the percentage of molybdenum consumed in stainless steel production remains fairly consistent at approximately 30 per cent of total consumption.

5.2.1.2 Other Steels and Alloys (Ferrous)

There are a number of key influencing factors in the forward consumption of molybdenum in other ferrous alloys and castings.

- **Global GDP Growth.** In accordance with projections provided by Abare, global GDP growth for the forecast period is expected to average 3.8 per cent per annum. Despite an expected slowing of the Chinese economy, annual growth is still forecast at approximately 8 per cent per annum.
- **Recovery of the Aerospace Industry.** The global aerospace industry is forecast to recover strongly in 2005.
- **Increasing Demand for Land Based Turbines.** The industrial gas turbine market will continue to grow rapidly due to increasing demands for power-plant construction.
- **Civil Transportation.** Increasing applications in the production of automotive and rail-wagons.
- **Ocean Going Transport and Offshore Construction.** Increasing applications in the production of vessels for the bulk transport of gases and chemicals. Also strongly increasing offshore applications particularly for the production of gas.
- **Price Structure.** A sustained period of high prices may encourage some substitution of molybdenum-based alloys. However most of these current alloys have high value in use equations, and therefore this substitution is expected to be minimal.

Over the past decade, average growth in this sector of the market has been 2-3 per cent per annum. However, during the review period of 2004/2009 potential growth could be as high as 6 per cent per annum, supported by the recovery of the aerospace and transportation industries in Europe and North America and increasing demand in China for transportation.

5.2.1.3 Chemicals and Other Non-Ferrous Applications

Whilst the same principals apply for growth in this sector of the molybdenum market, special mention of the catalysts market is required. Consumption of molybdenum based catalysts for both petroleum cracking and automotive have been growing at approximately 5 per cent per annum, and this trend is expected to continue.

Additionally non-ferrous alloys for use in the aerospace industry are expected to grow very strongly from the period of 2005-2007 with new construction already confirmed. In these applications, the value is extremely high, and even the current very high price structure will have no influence on demand.

6.0 MOLYBDENUM PRICES

Current ‘western’ market prices for both molybdenum oxide and ferro-molybdenum are at historically high levels. As at June 2005, traded prices for oxide are US$38.50 per pound and US$39.89 for ferro-molybdenum.

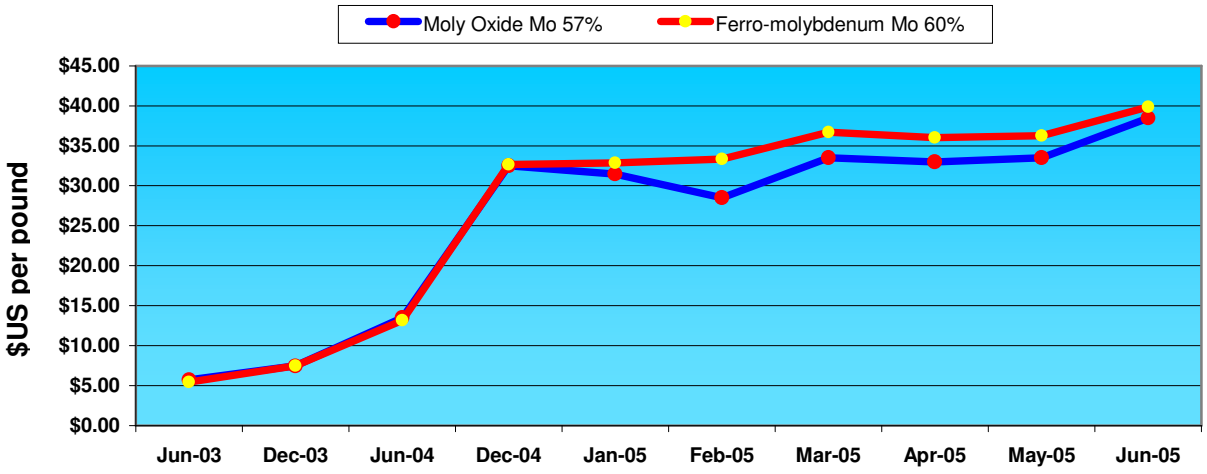
A review of historical pricing structures suggest these current price levels are well outside average price structures, and therefore unlikely to be sustained. The current price levels have been caused by a number of coinciding factors.

- Shortages in supply due to a downturn in copper production over the past few years, and particularly by producers in South and North America, which are the main producers of molybdenum as a by-product.
- Anti-dumping actions in Europe and North America against Chinese material.
- A strong surge in stainless steel production, and particularly the production of duplex stainless steels, which have high molybdenum content.
- Western European steel producers unable to accept Chinese ferro-molybdenum due to lower quality and high lead content.
- Primary molybdenum producers in USA being unwilling to restart dormant capacity and in the expectation that as copper production is increased, molybdenum will again become oversupplied and prices will fall as rapidly as they have increased.

Even including the current price structures for 2004, the average price for molybdenum oxide over the past decade has been US$2.70 per pound.

This type of pricing behaviour is entirely consistent with other products where the majority of supply is achieved as a by-product of an alternative primary product. (In this case copper). The only additional complexity with molybdenum is the current anti-dumping actions against Chinese material in Europe and North America, which was designed to protect primary domestic producers.

Figure 4 - Price Structure June 2003 – June 2005



Source: Asian Metal

Products operating under this regime tend to have long periods of oversupply, with resulting suppressed prices, followed by very short periods of very high prices if there has been some interruption to the by-product supply program.

The current prices do however underline that molybdenum has a very high value in most applications, and short-term substitution is difficult.

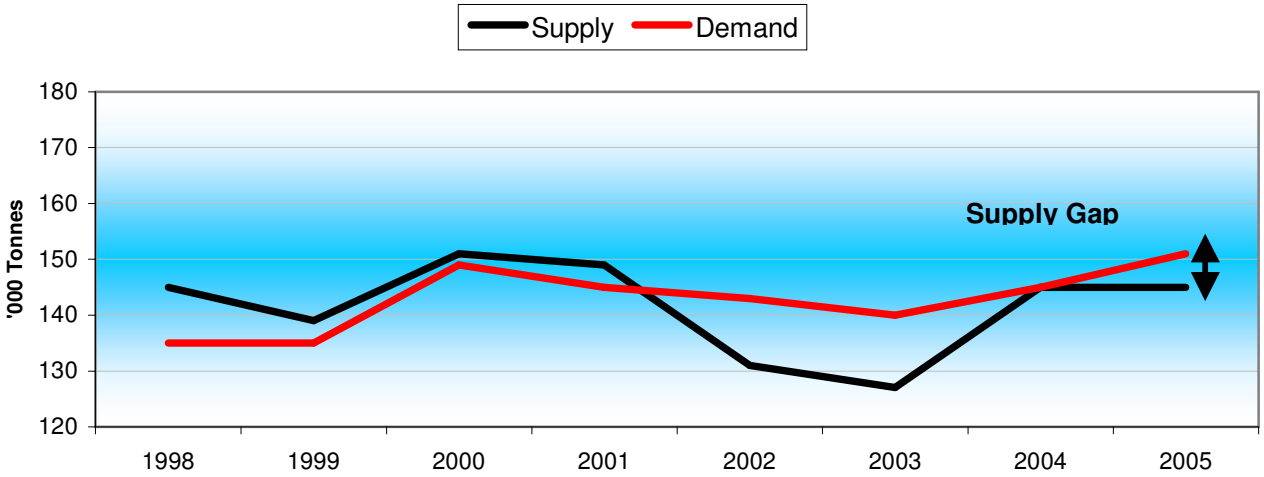
7.0 FORWARD OUTLOOK

In accordance with previous growth programs, it has been assumed that global consumption of molybdenum will continue to grow at approximately 4 per cent per annum (average). This assumption is based upon the following parameters.

- Global GDP growth is forecast at 3.8 per cent per annum. Growth in steel production will be similar.
- Growth in catalysts will continue at approximately 6 per cent per annum.
- Strong growth in China will continue, albeit at a more conservative rate.

Assuming these growth programs, Figure 5 summarises the developing supply gap based upon existing production and forecast requirements.

Figure 5 – Supply Gap 1998 - 2005



In order to match this increase in consumption, and cover the exisiting supply gap, production will need to be increased. This is lilkely to occur within the following parameters.

- **Copper Production**. Over the past five years, and as a direct result of depressed prices, copper production has been reduced particularly in USA and Chile. However, commencing during 2004, copper prices recovered and are forecast to remain firm. Most industry analysts believe a strong copper market will prevail for at least the next three years, as a direct result of a surge in demand from China.

  Chile and USA are now considered the 'swing' producers of copper and with the upturn in demand, increased production in both these countries is expected. In turn this will provide increased molybdenum production, however the exact quantities will depend upon which copper mines are returned to full production.

- **Chinese Production**. China has already demonstrated their ability to supply large quantities of low cost material, and with the world's largest reserves, it must be assumed that increases in production will be achieved.

- **USA Primary Production**. At least to date, the current very high prices have not tempted these companies to restart idle mining operations, and we can only assume this is due to the fact that they also believe increased copper production will quickly bring the market back to balance, and back to a price level that prevailed from 1994 to 2003. However, it remains possible that a sustained period of high prices may encourage some increased output from these producers.

Due to the aforementioned factors, confirming regional supply programs during the forecast period is difficult, and a number of alternatives are possible. However with a number of alternatives available, it must be assumed that production will eventually be

increased to match global demand. However this is likely to take some time to be reasilsed, and the 'short-term' market is likely to remain tight until at least the end of 2005.

8.0 BUSINESS OPPORTUNITIES

Global demand for molybdenum is currently outstripping supply, or at least in the major 'western' markets of Europe and USA that are protected from low cost Chinese material. In turn, with the opportunity for substitution limited, prices of both molybdenum oxide and ferro-molybdenum have climbed to historically high levels during the past year, and to almost seven times the historical average over the past decade.

For potential producers, this would suggest an ideal opportunity to enter the market, and based upon traditional cost structures for even primary molybdenum producers, the returns should be extremely positive.

However, consistent with many other products that are produced mainly as a by-product, and supported by a limited number of primary producers, the current very high price structure is expected to be short lived. In fact, this has been the history of molybdenum, and during the past decade there have been several short periods of very high prices, followed by long periods of oversupply and suppressed prices.

Global reserves of molybdenum are massive, and almost by coincidence, the largest reserves are located in the two largest consuming countries, being China and USA. In turn the opportunity to competitively supply to these markets in the longer term appears restrictive. Similarly, Japan, which is the other major market in the region, is geographically best serviced by the Chinese producers.

In turn the business opportunity for potential Australian producers to produce molybdenum as a primary product, particularly over the longer term, appears to be limited, with the prospect of facing increasing competition from molybdenum as a copper by-product, and low cost producers from China.

However if it is possible to develop a production program as either a by-product or co-product, and acceptable net returns were achievable based upon a forward price structure of US$4.50 to US$5.40 per pound, then a positive and sustained entry to the market should be achievable. An alternative strategy may be to consider downstream processing.

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