

# MOLYBDENUM

*By Brian Nolk*

Booming demand and rising prices were clear features of the molybdenum market throughout 2004, and production soared as a result. Global production of molybdenum jumped by approximately 11% to 139,000 t, from 125,000 t in 2003, but it was the North American producers who were responsible for most of the increased output. Production in Canada and the US jumped by over 20% to nearly 50,000 t in 2004 as mothballed capacity was rushed back into service.

Despite the dramatic increases by some producers in the US and Canada and by other, smaller increases in Chile and Peru, the global appetite for molybdenum products outstripped supply for the third year running. Asia was the hottest market but demand in Europe and the US was also strong as stainless and specialty steel production rose.

The result was a steady run up in the transaction price of molybdic oxide and ferro-molybdenum, with the benchmark *Metal Bulletin* drummed oxide free market in warehouse price starting the year at around US\$7.00/lb and ending 2004 at US\$32-34 per lb.

This was a dramatic turnaround for the molybdenum market, which had seen ample free-market supplies and steady low prices for some years. Until late 2001, the factors which kept molybdenum in oversupply included strong by-product output from copper operations in the US, Canada, Chile and Peru, as well as continuing supplies from China. Free-market price indications for molybdic oxide were locked into a range of US\$2.00–US\$3.00/lb Mo for several years up to early 2002. Since 2002, however, market prices have risen dramatically and by the end of 2004 the price for free-market oxide in Europe was just under US\$30/lb, with ferromolybdenum basis 65-70% Mo at over US\$90/kg.

Since some 75% of the world's molybdenum enters the supply chain as a result of by-production from porphyry copper operations there is little the molybdenum industry can do directly to affect market balance. As a result, the few but relatively large primary producers in the US were relegated in the 1990s to being 'swing' producers, able to participate only during the brief periods of supply dislocation and price rises. Just such a price rise began in mid-2002.

## **Supply**

From the previous price spike in 1994 until 2002 the molybdenum market was in oversupply, as exports from CIS producers entered the world market alongside increased output from China and South America. As free-market molybdenum prices languished in the doldrums, around US\$2.25–US\$3.00/lb, North American primary producers and by-product

producers steadily cut back output from 1998 until 2003. However, this has been largely offset by new by-product output from South American copper operations, such as Los Pelambres in Chile. Latin American output has jumped by one-third since the mid-1990s, offsetting cuts of one-third and one-half in Canada and the US, respectively.

From a peak of 138,820 t (306 Mlb) in 1997, world production reached a low of 125,070 t (276 Mlb) in 1999, before climbing back slightly to 130,000 t (286.6 Mlb) in 2001 (Table 1). Production in 2004 is estimated to have totalled 139,000 t (306 Mlb).

## **US**

For many years the US was the world's largest producer of molybdenum, although with cuts in US output since 1998 and growth in other producing nations, it looked for a time as though the US might drop to second place behind Chile. However, the US has enormous reserves and substantial copper-molybdenum production capacity that was placed on standby during the lean years, so the potential was always present for the US to regain its production supremacy. Production estimates for 2003 and 2004 gave the impression that Chile was likely to supersede the US. We await revised statistics from the US Geological Survey to see what actually happened in the production league table.

What is clear is that US production of molybdenum came back with a thump in 2004. Estimates from the USGS suggest that US molybdenum production for 2004 jumped by 19% to approximately 40,000 t, or nearly 88 Mlb.

A significant proportion of mine capacity in the US is accounted for by primary molybdenum mines and output at these mines can fluctuate according to price and perceived demand. The primary mines at Henderson, Thompson Creek and Questa in the US, and Endako in Canada, have reduced output since the late 1990s to help offset rising stocks of molybdenum in the market. Also, many of the copper-molybdenum operations curbed output though 1996-2002 because of a combined lull in the markets for both copper and molybdenum.

Phelps Dodge, through its subsidiary Climax Molybdenum, is still the world's largest molybdenum producer. Its Henderson underground primary molybdenum mine in Colorado produced 27.5 Mlb in 2004 (up from 18.6 Mlb in 2001) and this output was supplemented by molybdenum units from its Sierrita and Bagdad copper mines in Arizona which, together, produced nearly 30 Mlb of molybdenum in 2004 as a by-product of the company's copper operations. The Bagdad and Sierrita mines were returned to full production capacity, thus increasing their output of byproduct molybdenum. The company said it produced 57.5 Mlb of molybdenum from its own mines in 2004 (up from 52 Mlb in 2003), and sales of its own production totalled 63.1 Mlb (54.2 Mlb).

There are plans to increase output further at Henderson in 2005; perhaps to 40 Mlb, and even the Climax mine in Colorado, which has been shut down for a decade, could reopen in 2005, with reports of that mine alone adding another 10-20 Mlb/y of molybdenum to the market.

Thompson Creek Metals operates the Thompson Creek mine near Clayton, Idaho, the Endako joint venture (with Nissho Iwai) in British Columbia and conversion plant at Langeloth, Pennsylvania. Thompson Creek's Idaho production is thought to be close to its stated 15 Mlb/y capacity, despite some mining problems concerning lower-than-expected ore grades in the first half of the year. Production at Endako was expected to remain at the previous year's level of roughly 10 Mlb.

Rio Tinto's Kennecott operation at Bingham Canyon in Utah produced approximately 6,800 t of molybdenum in 2004, up from 4,600 t in 2003. This year production has continued to climb and in the first quarter of 2005 alone the unit produced 3,900 t of moly.

Montana Resources resumed mining at Butte, Montana, after a three-year shutdown and was on track to produce 7 Mlb of molybdenum in 2004.

### **Chile**

The production league table has changed, with the US regaining production dominance in molybdenum, and China and Chile have vied for second place. Chile has been the world's second-largest producer and the USGS estimates output at 33,400 t in 2004 but that may need to be revised upwards substantially once full figures are available. This compares with about 30,000 t in 2003. Almost all of Chile's molybdenum output is exported.

In Chile, and indeed in the rest of Latin America, molybdenum is produced solely as a by-product of copper mining. Over the past 20 years, as copper producers have increased their copper output, their molybdenum by-production has also risen. The increased molybdenum output from Latin America has, over time, offset the reduced output from 'swing' producers in North America.

Molibdenos y Metales (Molymet) announced at the end of 2004 that it is planning to increase its processing capacity to 150 Mlb/y by 2007, from its current capacity of 100 Mlb/y. Molymet produces molybdic oxide from concentrates produced at mines in Chile, Peru and Mexico.

Noranda Inc is also planning increased molybdenum production at its operations in Chile and Peru. At the Collahuasi mine in Chile, in which Noranda's subsidiary Falconbridge Ltd has a 44% stake, a new plant is being built capable of producing 12,000 t/y of concentrates, and production will commence in 2005.

A copper roasting unit at the Altonorte smelter near Antofagasta is being converted to molybdenum concentrate production, according to Noranda, with a capacity of 11,600 t/y.

In neighbouring Peru, molybdenum output at the Antamina mine jumped to over 3,500 t in 2004, and this will increase further in 2005.

It is assumed that concentrate output from these capacity increases at Noranda's South American units will feed into the enlarged oxide circuit at Molymet, as will other concentrates in the region.

High prices for molybdenum in recent years are prompting the hunt for the metal in every possible location. Amerigo Resources Ltd, a Canadian-listed junior mining company, said it is building a unit to recover molybdenum concentrates from the tailings reprocessing plant at El Teniente in Chile. Amerigo expects to produce 500,000 lb/y of molybdenum concentrates in 2005 at its Minera Valle Central subsidiary, and this will rise towards 1 0 Mlb/y in 2006.

### **China**

China is the third-largest producer of molybdenum in the world and in 2004 it produced approximately 31,000 t compared with 30,600 t in 2003. China's identified reserves of approximately 8.55 Mt puts it in second place in the world ranking of reserves. 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 (1.1 Mt); and Jinduicheng in Shanxi Province (970,000 t).

Production from the large number of small producers throughout China is erratic and some could close under tightening safety regulations, chronic energy shortages and pollution-related local initiatives. This, along with the inexorable rise in domestic demand for molybdenum products by the steel sector and other industries, is likely to have a major impact on China's molybdenum exports in coming years.

Another of the factors affecting Chinese exports of molybdenum is the European Union anti-dumping duties imposed on exports of Chinese ferromolybdenum to Europe. In 2001 the EU Council of Ministers voted to impose definitive 22.5% anti-dumping duties on all imports of ferromolybdenum from China in 2002 following a complaint from Euroalliages, a trade association of European ferro-alloys companies. The European Commission found that dumping of Chinese ferromolybdenum had led to European producers cutting production by 44%. (A provisional anti-dumping duty on imports from China had been imposed in August 2001, with varying rates up to 26.3%, but this was harmonised to 22.5%.)

In December 2004 Euroalliages said it would fight any review by the EC to reduce or eliminate the anti-dumping duties on Chinese ferromolybdenum, despite the massive increase in the prices seen for that material in 2004.

Luoyang Luanchuan Molybdenum Group began an expansion of its mining and concentrating facilities in mid-2002, raising output from 8,600 t/y of molybdenum concentrate to 10,000 t/y in the second half of the year. The group intends to use all of the increased output for its own ferromolybdenum and molybdenum oxide plants. In 2001, the group had the capacity to produce 3,000 t/y of oxide and 8,000 t/y of ferromolybdenum, most of it destined for the US and South Korean markets.

China's molybdenum market was subdued in the first half of 2004 but a shortage of export offers in March, triggered by rising internal demand from steels mills, saw European prices for oxide rise above US\$10/lb and ferromolybdenum prices to rise to over US\$30/kg by the end of March. Energy supply problems and heavy rains at some mining operations were also cited as reasons for reduced exports from China in mid-2004.

For Jinduicheng Molybdenum Mining Corp (JDC), heavy rains in mid-year prompted concerns that the tailings dam would collapse, even though the company undertook repairs in July. The JDC mine is located in Huaxian county in northwest Shaanxi, and the company's smelter is capable of producing 20,000 t/y of molybdenum oxide and downstream-related molybdenum products, plus 5,000-6,000 t/y of ferromolybdenum.

There were other supply-side pressures, including the closure of mines in Huludao and Zhejiang provinces, and the planned elimination early in 2005 of the 13% tax rebate on certain ferro-alloy exports, including ferromolybdenum. It was clear by the end of the year that safety concerns were prompting Chinese authorities to halt mining operations in Huludao and Shaanxi during the first quarter of 2005 in order to make safety checks, and that exporters were stockpiling against those closures.

## **CIS**

Molybdenum supply from the CIS recovered slightly, to 7,380 t in 2004. Producers in Armenia, Kazakhstan, Uzbekistan and Russia have had some difficulties in the past in getting their product to export markets but they were quick to spot the opportunity to sell ferromolybdenum into the EU market, where anti-dumping duties had halted imports of Chinese material. In Russia, Chelyabinsk Electrometallurgical Works restarted ferromolybdenum production after a two-year stoppage. The firm is toll-processing concentrates for export. The plant has a capacity to produce 20,000 t/y of ferromolybdenum.

The Sorsk operation was damaged by a fire in November 2003 and was out of the market for a large part of 2004. Sorsk produces 6-7Mlb/y of molybdenum concentrates, about half of which is exported to China and the rest exported to Western markets.

Uzmetal Technology Ltd finished the commissioning of its molybdenum metal powders and finished products plant. This joint venture between Israeli company Metek Metal Technology Ltd, and Almalyk and Uzbek Heat Resistant Metals, based at Almalyk Mining and Metallurgical Complex in Uzbekistan, commenced molybdenum production in 2002. The US\$19 million project is reported to use 600 t/y of molybdenum concentrates supplied by Almalyk for further processing at the Uzbek Heat Resistant Metals Combine in the city of Chirchik near Tashkent.

Cronimet, a German group, said it plans to double production at its 60%-owned Zangezur copper/molybdenum mine in Eriwan, Armenia in 2005-06. The operation produce over 50,000 t/y of copper in concentrate and about 8,000 t/y of molybdenum. Partners in the project, Pure Iron (15%) and Armenian Molybdenum Production (12.5%) will convert much of the material to ferromolybdenum

### **Western Europe**

In early 2002, Chile's Molymet acquired Belgian alloys producer Sadaci for €8.5 million from French group Eramet. Sadaci roasts molybdenum concentrates to produce a variety of products: oxides, ferromolybdenum and sodium molybdate (as well as ferrovanadium and manganese alloys).

Molymet is now one of the major global producers, with operations in San Bernardo, south of Santiago, Chile (annual capacity of 68 Mlb) and in Cumpas, in northern Mexico, known as Molymex (annual capacity of 22 Mlb of molybdenum oxide).

Molymet announced that by 2007 it will invest over US\$100 million to increase by 50% its roasting capacity at Sadaci and at its operation in Chile.

With Sadaci now dedicated to Molymet's production, there are huge strains on the European merchant market for molybdenum, since Sadaci had been largely used previously by traders as a tolling facility. Of the other three plants in Western Europe only Ferro-Molybdenum Ltd's plant in Glossop in the UK was left 100% dedicated to tolling but it closed in March 2004. In the Netherlands Climax has some capacity currently used for tolling, and in Austria Treibacher is thought to use all its existing capacity for its own account, although it did expand its output throughout the summer to help ease the acute supply shortage in the market.

The closure of the Glossop plant was a major shock to the European trader supply. The plant was shut in March owing to a storm that damaged part of the plant's roof. The plant converts molybdenum oxide to ferromolybdenum, which was in short supply in Europe in 2004. Reports that the plant would be re-opened quickly kept customers' hopes alive. However the operation was incurring heavy financial losses, attributed, amongst other things, to a miscalculation of the dollar/sterling hedge, and the plant was placed in administration; no more molybdenum

was produced in 2004. The 3,000 t–4,000 t/y of ferromolybdenum will be sorely missed by the market. The plant was formerly owned by Eastlink but there was a management buy-out in November 2003. Reports at the end of 2004 suggested the plant could be restarted in 2005 under new management.

Austrian ferromolybdenum producer Treibacher Industrie has over 5,000 t/y of spare ferromolybdenum capacity and by mid-year it announced an increase from its original production plan for the year to meet stainless-steel mill demand in Europe. Officials would not elaborate on how much of its unused conversion capacity would be used, saying this depended on the availability of molybdenum oxide at suitable prices.

Other European converters such as Climax in the UK and Sadaci in Belgium are thought to be running at full capacity. Climax, owned by Phelps Dodge, operates a ferromolybdenum conversion plant at Stowmarket, in Suffolk in the UK, but that plant was closed for a short period early in 2004 following an equipment failure in January.

International Molybdenum plc (InterMolybdenum) has received US\$4.8 million in initial financing to help fund a feasibility study at the Malmbjerg deposit in Greenland. It is reported that the operation could produce about 22.5 Mlb/y of molybdenum and that production could conceivably begin in three years.

On the political level, battle lines were drawn in mid-2004 by Euroalliages (the association of European ferro-alloy producers), which had helped to establish a 22.5% anti-dumping duty on import into the EU of Chinese ferromolybdenum, and the European Confederation of Iron & Steel Industries (Eurofer). Euroalliages, said it would resist all attempts to reduce or eliminate the duty. Molybdenum buyers said that, with ferromolybdenum prices at close to US\$100/kg compared with less than US\$10/kg when the duty was imposed in 2002, the protection makes no sense and indeed exaggerates an already miserably tight supply problem in Europe.

### **Demand**

In the past eight years, global molybdenum consumption has grown by approximately 2-3% per annum, and estimates for 2004 consumption generally fall in the range 135,000–142,000 t. US reported consumption last year rose by about 7% according to the USGS.

The iron and steel industry accounts for about 75% of molybdenum consumption, of which 30-35% goes to the stainless steel sector. The stainless-steel industry has enjoyed an annual growth rate of around 4% over the same period and this had helped molybdenum demand. The growing market for high-strength, low-alloy (HSLA) steels containing molybdenum has also been a good market for molybdenum and the International Molybdenum Association (IMOA) and others have promoted

the use of duplex steels, which contain relatively high levels of molybdenum.

The International Stainless Steel Forum (ISSF) said it believes the high prices for both nickel and molybdenum will cause an acceleration in the shift from austenitic grades of stainless steel to ferritic grade. ISSF figures for 2004 show the percentage use of CrNi grades standing at 65.6%, down from 70.8% in 2003, CrMn grades at 9.3%, up from 7.4% and Cr grades at 23.1%, up from 21.8%.

There are plenty of applications; notably many appliances and some, but not all, heating and automotive exhaust systems where ferritic grades are increasingly being used. Beyond the increases in molybdenum and nickel prices, the trend towards ferritic usage is also being driven by consistent demand for consumer goods at low prices in developing countries. Whereas a West European producer might produce as much as 30% ferritic grades, producers in the developing world may produce 50% ferritic grades or more.

Underlying stainless-steel demand projections are for a 6% increase year-on-year during the present cycle but a clear line of substitution away from the Ni/Mo grades seems to be evident, according to market reports.

The second-largest consuming sector for molybdenum after iron and steel is the catalyst industry (including automotive catalysts as well as industrial catalysts for the petroleum and petro-chemical sectors). Catalyst demand has grown by over 5% annually since 1990 and Roskill says annual growth is set to continue at around 3-4% through to 2005.

### **Consumption by end-use**

Although the stainless-steel and catalyst sectors have been largely responsible for much of the growth in world molybdenum demand since the mid-1990s, demand from the superalloys and molybdenum metal markets has also shown significant growth. Superalloys are used in aerospace applications, which account for around 75% of this market, but large turbines for the gas industry are a high growth area as well.

Geographically, Europe is the world's largest molybdenum-consuming region, accounting for around one-third of total demand in 2004. The size of the European stainless- and special-steel industries, as well as a growing catalyst production, is largely responsible for its dominance in this market. The US still consumes about 20% of all molybdenum and Japan a little less than 14%.

China's consumption is now thought to be over 7% of the global total and still rising. It is expected that rising Chinese demand for molybdenum could see that nation emerge as a net importer, as its steel industry continues to expand.

Molybdenum has a number of other metallurgical uses other than in steels – including alloys used in automotive, aerospace, gas turbine rotors and in chemical and nuclear applications. Molybdenum products are also used in chemical applications such as pigments, lubricants, smoke suppressants, corrosion inhibitors and catalysts.

Global molybdenum demand is predicted to grow by an annual 2-3% over the next few years. The highest growth rate is expected to come from non-metallurgical applications such as lubricants, pigments, water treatment, polymers and airbags, where demand is predicted to increase annually by about 3-4%, but these non-metallurgical applications still account for only about 7% of global demand at present.

### **Prices**

A look at the 20-year price graph for molybdenum shows it had a stable range of US\$2.00-5.00/lb for oxide and US\$6.00-12.00/kg (US\$2.70-5.40/lb) for ferromolybdenum. This 'natural range' has been exceeded only rarely in the past 20 years, notably in 1994-95 and much more dramatically since 2002. This was caused by a sharp rise in demand from growing world steel production, which molybdenum producers were unable to meet, coupled with delays and cancellations of exports from China.

The main reason behind the low molybdenum prices in the second half of the 1990s was the large stocks of material in the marketplace. The growing proportion of supply as a by-product of copper mining, and the concomitant reduction in the ability of primary mines to act as 'swing' producers, was also an important factor.

In 1999, the supply-demand balance changed, and in that year it is thought demand exceeded supply by as much as 6,000 t, bringing about the first drop in the large surpluses, which dogged the late 1990s. Further cuts in North American production in 2000 and 2001, and some growth in demand, saw a steady drawdown in the large global stocks of molybdenum products. However, until stocks had dropped by a significant amount there had been almost no movement in prices.

The price for molybdic oxide in drums started 2004 at about US\$6.80-US\$7.10/lb for in warehouse material Europe, and about US\$6.20-US\$6.30/lb for canned material in the North American market. The ferromolybdenum price started the year at about US\$17/kg Mo.

After a calm two months the market tightened in March as buyers found they could not source prompt material from China. Oxide prices by end March reached US\$12-US\$13/lb as a result, and ferromolybdenum rocketed to nearly US\$40/kg in April. After another pause in May the upward trend line resumed and by the end of the summer ferromolybdenum was back over US\$40/kg and oxide prices were rising steadily.

The graph tells the whole story. Consumers were reduced to buying only spot deliveries in the hope of prices dropping back, but tightness in the supply chain, largely prompted by strong demand and a shortage of Chinese material, kept prices rising. By year-end, ferromolybdenum was changing hands at US\$83-US\$86/kg and oxide prices were at a high of US\$32-US\$34.50/lb.

Major stainless-steel mills were quick to keep their 'molybdenum surcharges' in line with the underlying rise in molybdenum prices. This all came at a time when base prices for many stainless-steel products were on the rise anyway.

### **Outlook**

After years of ample supplies it is now clear that the molybdenum market entered a period of relative shortage in 2001-02 after drifting into a supply shortfall against consumption perhaps as far back as 1999. By 2004, the shortage was real, acute and difficult to unwind, and the prices seen in the merchant market nearing US\$100/kg for ferromolybdenum were honestly scary to many of the stainless-steel mill buyers.

It would appear that in such an environment the traditional 'swing' producers, such as the Henderson, Thompson Creek, Questa and Endako mines, will have a great deal of control over the future supply/demand balance for molybdenum. It was largely those operations and others within Phelps Dodge and Grupo Mexico which cut back sufficiently in 1999-2001 to help the market recover from the huge overhang of stocks which had caused the poor prices of the preceding six years. Those cutbacks took years to have an effect but at long last they have had a significant impact on prices.

Conversely, now that the 'swing' producers are jumping back into higher production rates on the back of improved prices, there is little doubt that the balance could be tipped back towards balance in 2005 thereby calming some of the jumpier consumers. However by its very nature the supply pendulum always swings too far and it is not incredible to imagine the molybdenum market back in oversupply by 2006-07.

The other significant factor in the supply/demand balance, and equally slow to be acknowledged, is the changing levels of Chinese molybdenum exports.

The higher levels of domestic consumption meant lower Chinese exports in 2004. The growing steel sector in China is expected to consume a progressively greater amount of domestic molybdenum production so it is possible that China may eventually become a net importer of molybdenum products. Certainly, as Chinese exports slow (even temporarily as in mid-2004) there is already a significant effect on free-market price levels.

The percentage of molybdenum production coming from copper-mining operations has grown by an annual average of around 2.5% since 1980 and was estimated at about 76% in 2000. Clearly, if this rising trend continues and prices remain in the range that has typified the past 20 years, the future of some primary molybdenum mines looks uncertain, particularly those in areas with high labour and energy costs. But a mothballed primary capacity, which is quick to jump on the prospect of higher prices, is also the immediate answer to any cries of shortage in the market.

The final factor on the supply side is recycling. Recovery of molybdenum units from spent catalysts is increasing because of environmental legislation that prevents the disposal of such catalysts. Catalyst recycling is estimated to be growing at 5% annually in Europe and North America, and by as much as 8% annually in the Asia/Pacific region. This is now equivalent to approximately 3,000 t/y of molybdenum.

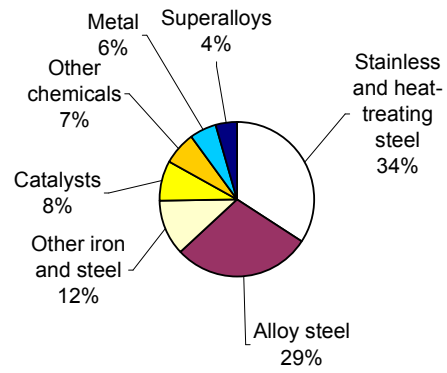
**Table 1**  
**Molybdenum Production ('000 t)**

	<b>2002</b>	<b>2003</b>	<b>2004e</b>
Canada	7.5	7.5	9.7
Chile	29.5	30.0	33.4
China	29.3	30.6	31.0
CIS <sup>1</sup>	7.38	7.35	7.38
Mexico	3.4	3.5	3.5
Peru	9.5	9.6	11.0
US	32.6	33.6	39.9
Others <sup>2</sup>	3.29	3.0	3.1
<b>Total</b>	<b>123.0</b>	<b>125.0</b>	<b>139.0</b>

Source: USGS Mineral Commodity Summaries. Note: Production from North Korea, Romania, Turkey and the former Yugoslavia is not included.

<sup>1</sup> Armenia, Kazakhstan, Kyrgyzstan, Russia and Uzbekistan. <sup>2</sup> Chiefly Mongolia and Iran. e estimate.

### **Consumption Pie Chart**



Source: Industry estimates.

Notes: Other iron and steel includes tool steel, high-speed steel, cast iron and welding rods. Other chemicals include lubricants, pigments, water treatment, polymers and airbags.