

BISMUTH

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Unlike 2003, when prices stagnated, every quarter in 2004 told a different story. The price of bismuth was in the range US\$2.90-3.30/lb during the first quarter, US\$3.60-3.70/lb in the second quarter, US\$3.65-3.80/lb in the third and US\$3.40-3.65/lb in the final quarter. With prices as low as US\$2.50/lb during 2003, increases in 2004 came as no surprise, and prices rose particularly rapidly during the first half. The summer slowdown in demand in Europe, where the majority of bismuth is consumed, eventually halted the increases. The Chinese built up their stocks and as a result prices eased off, finishing the year in the US\$3.40-3.65/lb range. This range has been maintained well into 2005.

Occurrence

China remains the world's leading miner, refiner and exporter of bismuth. Peru, followed by China, then Canada, possess the largest known resources (see table below). In Western countries, bismuth is produced mainly as a by-product of lead and copper mining, whereas in China, bismuth is produced mainly as a by-product of mining polymetallic ores in which tungsten is usually primary product, although it is also produced as a by-product in some tin and zinc operations. China also possesses one of the world's few primary bismuth mines. Elsewhere in the Asia-Pacific region, bismuth is produced in South Korea, Japan and Australia.

The principal Western mine sources of bismuth are located in South and Central America, and parts of Africa. (Quantities of bismuth are also received in lead bullion from Kazakhstan.) Mexico and Peru continue to be the largest Western producers. The Tasna mine in Bolivia remains mothballed; stable higher prices are needed if the mine is to re-open, with a minimum price of US\$3.50/lb deemed necessary or even, according to some rumours, a price in excess of US\$4.00/lb. Polymetallic deposits including Nico in Canada, Nui Phao in Vietnam and Bonfim in Brazil, could become significant new producers in the future.

Extraction

Bismuth is occasionally found in elemental form, but more usually as an oxide or sulphide. It is essentially produced as a by-product in the processing of lead or copper ores. Bismuth reacts in a similar way to lead in smelting operations and is extracted with the lead in lead bullion, which may contain as much as 10% Bi. In copper smelting, bismuth (and any contained lead) are partially volatilised in the dust and fumes, and these are sent to lead refineries for further treatment.

The bismuth extracted with lead bullion is removed, either by the Betts process or the Kroll Betterton process. In the Betts process, cast anodes of

lead bullion are electrolysed in a lead fluosilicate electrolyte to produce a lead cathode and an anode slime containing the bismuth. The slime is melted to produce a metal alloy and a bismuth-rich slag which is fluxed and reduced with carbon to produce copper matte and bismuth metal. In the more widely-used Kroll Betterton process, particularly favoured where the lead bullion contains 0.05-3.5% Bi, calcium and magnesium are added to the bismuth-rich lead charge. A calcium-magnesium-bismuth compound is precipitated, and fluxes are used to produce bismuth metal. The Betts process is used in Canada, South Korea and Japan, and the Kroll-Betterton process is used in Europe, Mexico, Canada and Australia.

In China, where bismuth is mainly associated with tungsten, a mixed concentrate is produced by gravity and/or magnetic separation, or by differential flotation techniques, and concentrates are smelted in reverberatory furnaces to produce crude bismuth for refining. The Chinese also convert concentrates imported from Russia, South America, South Africa and Kazakhstan.

In 1999 the US Geological Survey revised its estimate of Reserves (bismuth content of lead and copper deposits) and Reserve Base (economic reserves plus marginal and sub-economic reserves):

Country	Reserves (tonnes Bi)	Reserve base (tonnes Bi)
United States	9,000	14,000
Australia	18,000	27,000
Bolivia	10,000	20,000
Canada	5,000	30,000
China	20,000	40,000
Japan	9,000	18,000
Kazakhstan	5,000	10,000
Mexico	10,000	20,000
Peru	11,000	42,000
Others	15,000	35,000
Total	112,000	256,000

Source: USGS

Applications

No new significant applications for have been developed for bismuth during the past ten years. There are three main use categories: chemicals, alloys and metallurgical additives.

Replacement of lead by bismuth continues to be mentioned, but, for cost considerations, it is probably only realistic in higher-added-value applications.

Demand for bismuth vanadate in yellow pigments has remained stable since most metallic paints still contain lead. In the pharmaceuticals sector, small tonnages of bismuth are used in stomach remedies.

Bismuth use is growing in fusible alloys and lead-free solders, particularly in Japan, following a change in legislation. Free-cutting applications in the steel sector is steady in Europe and the US; no data from the Chinese steel sector are available.

Consumption

Chinese domestic demand for bismuth is rising and estimates put demand at 2,000-2,500 t/y. Mining & Chemicals Products Group (MCP) is constructing a bismuth chemicals plant in Shangyu, Zhejiang Province, and production is scheduled to start in early 2006. The majority of production will be for the fast-growing Chinese market, and, hopefully, a clearer picture on bismuth in China will be available in next year's review.

Metallurgical applications for bismuth grew strongly in 2004. The US market rebounded by over 20%, and burgeoning demand for steel in China boosted bismuth's use in free machining.

Japan's consumption of bismuth jumped. The reasons are not attributable to any one application, rather to an overall improvement in the economy, although the replacement of lead by bismuth in solders and greases is growing at a steady rate.

In the European Union, legislation concerning lead replacement could have a positive impact on bismuth demand in 2005-06.

Japanese imports (tonnes)

Country	2003	2004
South Korea	36	64
China	407	564
Belgium	135	66
Russia	-	-
United States	31	12
Peru	158	227
Total	767	933

US consumption (tonnes)

	1997	1998	1999	2000	2001	2002	2003	2004
Fusible Alloys	593	741	823	889	997	985	669	703
Metallurgical	252	335	340	346	373	383	742	1,110
Chemicals	655	884	855	861	829	814	650	554
Others	30	32	31	34	45	45	18	21
Total	1,530	1,992	2,049	2,130	2,240	2,230	2,080	2,420

Source: United States Geological survey

Outlook

At the time of writing (August 31, 2005) the price of bismuth is at an historic high in the range US\$4.25-4.55/lb. The main driver has been Chinese demand, and the Chinese are even talking about prices moving above US\$5.00/lb. The average price for 2005 is expected to be somewhere in the US\$4.50-5.00/lb range.

One area that might slow demand for bismuth is the substitution of the metal by other metals/materials in some applications. In the pharmaceutical sector, for example there are numerous substitutes, and also in the pigments and solders sectors. Also, bismuth can be replaced by resins in alloys used for holding metal shapes, and by selenium or tellurium in free machining in the steel sector.

Although bismuth is a mature metal, demand is growing steadily, and whilst new polymetallic deposits containing bismuth are being developed in Canada and Vietnam, new consumption is developing in Asia, as witnessed by MCP Group's new chemicals plant in China.