



2005 Minerals Yearbook

BISMUTH

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Bismuth was last produced domestically, as a byproduct of lead refining, at a Nebraska refinery that closed in 1997. The last stocks of bismuth held in the National Defense Stockpile were sold that same year. In 2005, all primary bismuth consumed in the United States was imported. Only a small amount of bismuth was obtained by recycling old scrap. The leading foreign producers of refined bismuth in 2005 were Belgium, China, Japan, Mexico, and Peru. Belgium had no mine production, and its sole bismuth producer refined metal from anode slimes, concentrates, and smelter residues and flue dust, all of foreign origin.

Bismuth consumption in the United States was estimated to be 2,340 metric tons (t), a decrease of 3% compared with that of 2004. As a result of an ongoing U.S. Geological Survey (USGS) analysis and evaluation of the bismuth market that began in 2003, end-use patterns for 2003, 2004, and 2005 contain different assumptions than in previous years. The estimated domestic consumption of bismuth for 2005 was about 49% for metallurgical additives for castings and galvanizing; 29% for bismuth alloys, fusible alloys, solder, and ammunition; 21% for chemical and pharmaceutical uses; and 1% for research and other uses (table 2).

In recent years, new uses for bismuth have been developed as a nontoxic substitute for lead. These include the use of bismuth in shot for water fowl hunting, lubricating greases, pigments, and solders.

The average annual dealer price for bismuth increased to \$3.91 per pound, an increase of 17% more than that of 2004. Strong world mine and refinery output especially from China helped to moderate the price increase in light of continuing steady to strong world demand.

The estimated value of bismuth consumed domestically was about \$20 million in 2005. That represents an increase of 13% compared with the value in 2004.

Legislation and Government Programs

The Safe Drinking Water Act Amendments of 1996 (Public Law 104-182) banned lead from all fixtures, fluxes, pipes, and solders used for the installation or repair of facilities providing potable drinking water since 1998. The ban prompted a conversion to plumbing alloys that contain bismuth rather than lead. Increased use of plastic pipe, however, has kept the use of bismuth-alloyed brass from growing more rapidly in plumbing applications.

Production

Domestic production of primary refined bismuth ceased in 1997. Some domestic firms continued to recover secondary bismuth from fusible alloy scrap in 2005, but secondary

production data were not available. Secondary production was estimated to be less than 5% of domestic supply during the year.

Consumption

The USGS surveys domestic bismuth consumption annually. The amount used by nonrespondents is estimated based on reports from prior years or on information from other sources. Accordingly, estimated bismuth consumption was about 2,340 t in 2005, a 3% decline from that of 2004 (table 1). The USGS is continuing to reevaluate the domestic bismuth market and canvassed companies; therefore, the use patterns for 2003, 2004, and 2005 contain different assumptions than those in previous years.

Consumption of bismuth in chemical uses (chemicals, cosmetics, and pharmaceuticals) in 2005 decreased by 15% compared with use in 2004. The leading use, metallurgical additives, experienced a 4% increase in consumption in 2005 compared with that in 2004. The alloys category of use registered a 3% decline in tonnage compared with that of 2004.

Although it has the crystal structure of a semimetal, bismuth is often considered a metal. This crystal structure, along with several of its other salient properties, makes it an ideal substitute for lead in extreme-pressure additives. These unique properties include expansion on solidification, the widest range between melting and boiling points among all metals, and the lowest thermal and heat conductivity. Bismuth is the most diamagnetic of all metals, the least toxic, and has the lowest absorption for neutrons; bismuth is also characterized as “soft” like lead.

Bismuth pharmaceuticals include the well-known bismuth salicylate (the active ingredient in the over-the-counter stomach remedies) and other bismuth medicinal compounds used to treat burns, intestinal disorders, and stomach ulcers in humans and animals. Bismuth nitrate is the initial material used for the production of most bismuth compounds. Other applications of bismuth chemicals and compounds include uses in superconductors and pearlescent pigments for cosmetics and paints.

Bismuth metal is used primarily as a major constituent of various alloys and as a metallurgical additive (table 2). One class of bismuth alloys consists of fusible (low-melting-point, as low as 20° C) alloys—combinations of bismuth with other metals, such as antimony, cadmium, gallium, indium, lead, and tin. Applications for those alloys include fuel tank safety plugs, holders for optical lens grinding, and other articles for machining or grinding, solders, and fire sprinkler triggering mechanisms.

In addition to lead-free solder noted above, bismuth has long been a substitute for the lead added to certain steel products to provide greater machinability. A major domestic steel producer began to use a bismuth-containing substitute for the leaded alloy about 25 years ago. Although bismuth has been successfully

used in replacing lead in various applications, it has been challenged as a lead substitute by tin and tungsten (Cusack, 1999). Bismuth is also added in small amounts to aluminum (along with lead) and copper alloys to improve machinability. Also, it is added to malleable iron graphite flakes. These uses constitute the traditional metallurgical additives category.

Price

In 2005, the average dealer price for bismuth rose to \$3.91 per pound, an increase of 17% from the average price of \$3.35 per pound in 2004. The average annual price has experienced a steady and substantial rise starting in 2003.

The weekly price started 2005 at \$3.40 to \$3.70 per pound, then rose steadily through the third quarter to end at \$4.40 per pound. Continued rises in the fourth quarter took the price to \$4.65 per pound by yearend.

Trade

U.S. bismuth exports by weight rose about 31% from those of 2004. By value, the 2005 exports were almost twice those of 2004. While bismuth prices rose moderately for the year, the almost doubling in the value of exports was because of shifts in the types of value-added bismuth products exported. Measured by weight, notable export increases were recorded in 2005 by Belgium and Canada, while substantial decreases were experienced by the Dominican Republic, Japan, and Mexico (table 3).

Total U.S. bismuth imports increased 28% by weight and 41% by value in 2005 compared with the prior year's figures (table 4). Bismuth imports were 18 times greater, by weight, than bismuth exports. The leading import source for the United States was Belgium, which supplied 42% of imports. Considerable increases in imports were observed for Belgium, China, and the United Kingdom. Notable decreases in imports were recorded for Germany, Hong Kong, and Peru.

World Review

In much of the world, bismuth is produced as a byproduct of smelting lead ores. In China, it is also a byproduct of fluor spar, tin, and tungsten ore processing. In Bolivia, the Tasna Mine, the only mine that produces bismuth from bismuth ore, has been on standby since the mid-1990s awaiting a sufficient rise in the metal price. There are several other deposit types that may be developed in the near future that would have bismuth as a coproduct.

World refining production of bismuth increased by 20% in 2005 (table 5). China was the world's leading producer of refined bismuth with 71% of the world total, followed by Mexico with 8%, and Belgium with 7%.

Belgium.—Sidech S.A. (Tilly, Belgium), a leading refiner of bismuth and other minor metals such as indium, selenium, and tellurium, announced that it had been approved for membership in the Minor Metals Trade Association (MMTA). Siddech's inclusion into the MMTA brings MMTA's total membership to 70 firms (Metal Bulletin, 2005b).

Canada.—Fortune Minerals Ltd. in London, Ontario, Canada, continued to report progress at its NICO gold-cobalt-bismuth deposit, located 160 kilometers northwest of the city of Yellowknife, Northwest Territories. Fortune announced that it had entered into an agreement with Mindecom Industrial Contractors Ltd. to purchase the mill and certain other buildings from the Golden Giant Mine at Hemlo, Ontario, currently owned by Newmont Canada Ltd., for \$2.8 million. The Hemlo facilities would be purchased for use at Fortune's 81%-owned NICO deposit. The deposit was expected to be mined by a combination of underground and open pit methods, and the ore would be processed in a 3,000-metric-ton-per-day mill and hydrometallurgical plant to produce bismuth concentrate, cobalt cathode, and gold dore. The deposit was estimated to contain about 34,500 t (76.5 million pounds) of bismuth (Fortune Minerals Ltd., 2005).

China.—Reports from China, the world's leading bismuth-producing country, indicated that raw materials shortages continued to hamper bismuth smelters. Ore supply has become increasingly tight as existing mines are exhausted, and new discoveries are lagging. China's leading bismuth producer, Hunan Shizhuyuan Nonferrous Metals Co., expected its bismuth production to be 10% lower in 2005 than in 2004 and another 20% lower in 2006 than in 2005. China's refined bismuth production is about 8,500 metric tons per year (t/yr) but may well decline in coming years owing to mine depletion and falling bismuth content in ores. While large producers are facing production cuts, some smaller privately owned smelters are struggling to survive. Yongxin Daxin Nonferrous Metals Co., a private smelter in Chenzhou, Hunan Province, may close at yearend 2005 because of difficulties in sourcing raw materials. Bismuth-rich mines in China have largely been exhausted by extensive mining, and ores that are available domestically and from overseas, such as Africa and South America, are often too expensive (Metal Bulletin, 2005a).

A 300-t/yr bismuth production facility began operation in Chifeng City, Inner Mongolia, in June. The plant was funded by Yunnan Copper Bismuth Co., a joint venture between Yunnan Copper Co. and two large-scale bismuth producers in Chenzhou, Hunan Province. Another facility located in the industrial zone of Yunnan Copper Co. in the Dongchuan District, was expected to start production in late 2005. Upon completion of the project, the combined capacity of the three production facilities would reach 1,000 t/yr (Beijing Antaike Information Development Co., Ltd., 2005§¹).

Mongolia.—Canadian-based exploration company QGX Ltd. acquired a 100% interest in the Undur Tsagaan property in Khenti Province in northeast Mongolia. The prospect was thought to be the largest known occurrence of molybdenum and tungsten in Mongolia. Earlier (1979-82) drilling and exploration work by Russian and Mongolian exploration teams estimated resources of 141 million metric tons (Mt) containing 0.03% Be and 0.08% Bi, and resources of 60 Mt containing 0.11% WO₃, 0.03% Mo, 0.03% Be and 0.01% Bi (QGX Ltd., 2005).

Vietnam.—Tiberon Minerals Ltd. in Toronto, Ontario, Canada, announced that it increased its expenditures in 2005 on

¹A reference that includes a section mark (§) is found in the Internet Reference Cited section.

development of its Nui Phao project in Vietnam. The increase in development and exploration expenditures was owing to the advanced stage of the project and the completion of the final feasibility study. Tiberon's primary interest in the Nui Phao property is fluorspar and tungsten, but there are also promising quantities of bismuth. The latest study concluded that open pit mining will probably produce 3.5 Mt of acid-grade fluorspar concentrate, 76,000 t of tungsten trioxide, and 32,000 t of bismuth during a 16-year mine life. Tiberon holds a 77% interest in the Nui Phao project. Tiberon and its two Vietnamese partners, Thai Nguyen Mineral Co. (15% interest) and Export-Import Investment Company Thai Nguyen or "Intraco" (8% interest) formed the Nui Phao Mining Joint Venture Co. Ltd. to develop and operate the mine (Tiberon Minerals Ltd., 2006).

Outlook

Worldwide bismuth demand appeared to be increasing at about 3% to 5% per year. Demand for bismuth in the steel sector, although relatively minor compared with other use sectors, appeared to be increasing. World consumption in the chemical field seemed to be rising, especially in Japan, as bismuth there was starting to replace lead in pigments.

Commercial and research organizations in Europe, Japan, and North America agreed to a framework to eliminate lead from solders in manufacturing. This agreement would tend to increase the demand for bismuth during the next several years. Many Japanese manufacturers are using lead-free solder in some or all of their soldering applications, and studies on how best to develop lead-free solders were being performed independently by the European Union, Japan, the Republic of Korea, and the United States. Although world lead consumption was expected to be reduced by only 0.8%, world bismuth consumption will probably increase by about 25% with a move to lead-free solders.

A significant near-term increase in supplies of lead byproduct bismuth was unlikely because total world production of lead was expected to remain relatively stable, and an increasing portion of lead demand was expected to be met by recycling. A global shortage of bismuth, however, was not anticipated.

In China, where bismuth is a byproduct of fluorspar, lead, tin, and tungsten and processing, new technologies applied to this resource have increased world bismuth reserves. Therefore, despite possible large increases in world demand, Chinese supplies can be expected to help keep the bismuth market stable.

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Other

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TABLE 1
SALIENT BISMUTH STATISTICS¹

		2001	2002	2003	2004	2005
United States:						
Consumption	metric tons	2,200	2,320	2,120	2,420	2,340
Exports ²	do.	541	131	108	109	142
Imports for consumption	do.	2,220	1,930	2,320	1,980	2,530
Price, average, domestic dealer	dollars per pound	3.74	3.14	2.87	3.35 ^r	3.91
Stocks, December 31, consumer	metric tons	95	111	279	134 ^r	136
World:						
Mine production, metal content ³	do.	5,100 ^r	4,700 ^r	5,100 ^r	5,600 ^r	5,500 ^e
Refinery production ⁴	do.	5,800 ^r	6,700 ^r	8,700 ^{e,r}	10,000 ^{e,r}	12,000 ^e

^eEstimated. ^rRevised.

¹Data are rounded to no more than three significant digits.

²Comprises bismuth metal and the bismuth content of alloys and waste and scrap.

³Excludes the United States.

⁴Excludes Canada.

TABLE 2
BISMUTH METAL CONSUMED IN THE
UNITED STATES, BY USE¹

(Metric tons)

Use	2004	2005
Chemicals ²	584	498
Bismuth alloys	703	685
Metallurgical additives	1,110	1,150
Other	22	14
Total	2,420	2,340

¹Data are rounded to no more than three significant digits; may not add to totals shown.

²Includes industrial and laboratory chemicals, cosmetics, and pharmaceuticals.

TABLE 3
U.S. EXPORTS OF BISMUTH METAL, ALLOYS, AND WASTE AND SCRAP,
BY COUNTRY¹

Country	2004		2005	
	Quantity (kilograms, metal content)	Value (thousands)	Quantity (kilograms, metal content)	Value (thousands)
Argentina	--	--	240	\$57
Belgium	2,720	\$67	17,000	69
Brazil	1,140	156	4,260	112
Canada	46,000	812	70,100	870
Chile	--	--	1,560	34
China	99	3	35	6
Colombia	--	--	39	7
Dominica	53	9	--	--
Dominican Republic	11,100	664	5,420	219
France	--	--	10,100	2,300
Germany	1	3	--	--
Guatemala	229	4	--	--
Hong Kong	360	70	234	43
Israel	--	--	50	12
India	--	--	2,000	23
Ireland	--	--	618	8
Italy	113	18	--	--
Japan	5,320	102	2,100	84
Korea, Republic of	75	5	293	15
Malaysia	--	--	11	3
Mexico	28,500	488	17,400	843
Russia	2,090	33	--	--
Singapore	59	20	160	5
South Africa	--	--	98	6
Spain	--	--	1,000	10
Taiwan	--	--	49	8
United Kingdom	10,700	48	8,840	26
Total	109,000	2,500	142,000	4,760

-- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 4
U.S. IMPORTS FOR CONSUMPTION OF METALLIC BISMUTH, BY COUNTRY¹

Country	2004		2005	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Bahamas, The	1,910	\$12	2,620	\$25
Belgium	793,000	5,740	1,050,000	8,360
Canada	8,760	664	7,370	72
China	169,000	1,280	667,000	5,490
Germany	162,000	809	18,500	199
Hong Kong	77,100	722	--	--
Italy	--	--	106	25
Mexico	495,000	3,310	480,000	3,750
Netherlands	232	25	4	2
Peru	39,800	298	--	--
Russia	52	12	--	--
Spain	500	6	700	10
Switzerland	--	--	1	4
United Kingdom	237,000	1,640	304,000	2,550
Total	1,980,000	14,500	2,530,000	20,500

-- Zero.

¹Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 5
BISMUTH: WORLD MINE AND REFINERY PRODUCTION, BY COUNTRY^{1,2}

(Metric tons)

Country	Mine					Refinery				
	2001	2002	2003 ^c	2004 ^c	2005 ^c	2001	2002	2003 ^c	2004 ^c	2005 ^c
Belgium ^c	--	--	--	--	--	700	1,000	1,000	800	800
Bolivia	8	20	72 ³	62 ^{r,3}	60	66	88	88	33 ^{r,3}	30
Bulgaria ^c	40	40	40	40	40	40	40	40	35 ^r	35
Canada ⁴	258	189	145	145	190	250 ^e	250 ^e	250	250	250
China ^c	2,000 ^r	2,000 ^r	2,500 ^r	3,000 ^r	3,000	2,000 ^r	3,000 ^r	5,000 ^r	7,000 ^r	8,500
Italy ^c	--	--	--	--	--	5	5	5	5	5
Japan ^{e,5}	28	24	26 ^r	23 ^r	27	551	474	513 ^r	522 ^r	530
Kazakhstan ^c	252	161	150	150	140	130	130	130	130	120
Mexico	1,390 ⁶	1,126	1,064 ³	1,064 ^{r,3}	970	1,390	1,126	1,064 ³	1,064 ^{r,3}	970
Peru ^c	1,000	1,000	1,000	1,000	1,000	640 ³	568 ³	600 ^r	600	600
Romania ^c	40	40	40	40	40	35	35	35	35	35
Russia ^c	50	50	50	50	50	10	10	10	10	10
Serbia and Montenegro ^c	2	2	1	--	--	--	--	--	--	--
Tajikistan	5	--	--	--	--	--	--	--	--	--
United States	-- ^r	-- ^r	-- ^r	-- ^r	--	--	--	--	--	--
Total ⁷	5,100 ^r	4,700 ^r	5,100 ^r	5,600 ^r	5,500	5,800 ^r	6,700 ^r	8,700 ^r	10,000 ^r	12,000

^cEstimated. ^rRevised. -- Zero.

¹Estimated data are rounded to no more than three significant digits.

²Table includes data available through April 4, 2006. Bismuth is produced primarily as a byproduct of other metals, mainly lead and tungsten.

³Reported figure.

⁴Figures listed under mine output are the metal content of concentrates produced, according to Natural Resources Canada, 2004-05.

⁵Mine output figures have been estimated to be 5% of reported metal output figures.

⁶Refined metal plus bismuth content of impure smelter products.

⁷World totals are rounded to no more than two significant digits.