

# BISMUTH

By Robert D. Brown, Jr.

**The domestic survey data and tables were prepared by Carolyn F. Crews, statistical assistant, and the world production tables were prepared by Ronald L. Hatch, international data coordinator.**

U.S. bismuth consumption increased in all sectors during 1998. For many years, most of the bismuth consumed in the United States was imported. In 1998, however, all primary bismuth consumed in the United States was imported. The only domestic refinery, in Nebraska, produced bismuth as a byproduct of lead refining until July 1997. On November 7 of that same year, the last stocks of bismuth held in the National Defense Stockpile (NDS) were sold. The largest foreign producers of refined bismuth are Belgium, China, Mexico, and Peru.

Domestically, about 44% of bismuth was used in pharmaceuticals and chemicals, 37% in bismuth alloys, 17% as metallurgical additives, and 2% for other uses (table 2). Total domestic demand increased significantly in all sectors—33% overall. Only a small amount of bismuth was obtained by recycling old scrap.

In recent years, several new uses for bismuth have been developed as nontoxic substitutes for lead in various applications. These included the use of bismuth in brass plumbing fixtures, ceramic glazes, crystalware, fishing sinkers, lubricating greases, pigments, and solders. Bismuth was a leading candidate for replacing lead in applications that have an environmental impact, such as shot used in waterfowl hunting. Although this has been the only application showing a consistent, significant increase in demand as a substitute for lead, the use of bismuth as a replacement for lead in free-machining plumbing brasses also increased.

In 1998, following 2 years of decreases, the average New York dealer price for bismuth rose to \$3.60 per pound (table 1). The value of bismuth consumed domestically was about \$16 million.

## Legislation and Government Programs

The Defense Logistics Agency, which administered the NDS, sold the final 85 metric tons of bismuth in the NDS on November 4, 1997. On January 1, 1998, the NDS contained no bismuth.

The year 1998 was significant for bismuth in environmental law. The driving force for conversion to plumbing alloys that contain bismuth rather than lead was the Safe Drinking Water Act Amendments of 1996 (Public Law 104-182). This law bans lead from all fixtures, fluxes, pipes, and solders used for the installation or repair of facilities providing water for human consumption after August 1998.

## Production

ASARCO Incorporated, formerly the only domestic producer of primary bismuth, ceased production on June 30, 1997. Some firms continued to recover bismuth from fusible alloy scrap in 1998, but secondary production data were not available. Secondary production was estimated to be 5% or less of the domestic supply.

## Consumption

Domestic bismuth consumption data are collected by the U.S. Geological Survey through a voluntary canvass. Of the 44 firms that received the consumption survey form in 1998, 75% responded. The respondents accounted for an estimated 80% of the bismuth consumption in the United States. The amount used by the nonrespondents was estimated on the basis of reports from prior years or information from other sources.

Bismuth consumption increased in all sectors of the market in 1998 (table 1). Chemical uses, formerly composing most of the bismuth consumed, accounted for less than one-half of the bismuth used domestically for the second year in a row. The best known chemical use is that of bismuth subsalicylate, the active ingredient in over-the-counter stomach remedies. A novel, previously undocumented use for this product has been found—applying it to a cold sore appeared to promote healing (Goldstein, 1998). Other bismuth pharmaceuticals were used to treat burns, intestinal disorders, and stomach ulcers; veterinary applications were important as well. Bismuth nitrate was the starting material for the production of most other bismuth compounds. Other bismuth chemical and compound uses included applications ranging from superconductors to some pearlescent pigments in cosmetics and paints.

Bismuth metal use is categorized as bismuth alloys, metallurgical additives, and other uses (table 2). One class of bismuth alloys comprises the fusible (low-melting-point) alloys—combinations of bismuth and other metals, such as cadmium, gallium, indium, lead, and tin. Applications for these alloys included fuel tank safety plugs, holders for lenses or other parts for machining or grinding, solders, and sprinkler triggering mechanisms. Also included in bismuth alloys is the metal used to produce shot for waterfowl hunting.

Bismuth was added in small amounts to aluminum, copper, and steel alloys to improve machinability. It was also added to

malleable iron to prevent the formation of graphite flakes.

Interest remained high in using bismuth as a nontoxic substitute for lead in several applications. Bismuth oxide has been replacing lead oxide in the fire assaying of precious metals, lead in ceramic glazes, and lead and steel in shotgun pellets.

Bismuth has been the primary candidate for substitution when researchers seek to replace lead in products that traditionally have contained lead, such as plumbing fixtures and solders. Production began and research was continuing on the use of bismuth (often in combination with selenium) to replace lead in plumbing brasses. Although this strategy appeared to be the most promising metallurgical approach to meeting more-stringent tap-water standards in the United States, bismuth consumption for this application did not increase rapidly in 1998.

There is a drive to replace lead additions generally, such as the lead added to steel to provide greater machinability. One major domestic steel company began to offer a bismuth-containing substitute for the leaded alloy nearly 20 years ago. Although bismuth has been successful in replacing lead in various applications, it is now being challenged by tungsten and tin (Metal Bulletin, 1998e). Since 1994, one area of large, steady increases has been the use of bismuth alloy cartridges for waterfowl hunting; the alloy used was 97% bismuth and 3% tin.

## Prices

The domestic dealer price for commercially pure bismuth, published by Platt's Metals Week, averaged about \$3.60 per pound for the year, representing a 3% (\$0.10) increase after decreases of 4% in 1997 and 5% in 1996 (table 1). The price was \$3.33 per pound at the beginning of 1998, having fallen steadily during the second half of 1997 from a \$3.90-per-pound high during the second quarter. The price rose steadily during the first quarter of 1998, reaching the year's high of \$4.08 per pound. Beginning in April, the price drifted down for the rest of the year, reaching \$3.15 per pound. For the second year in a row, this second-half decline indicated expectations of adequate world supply despite the termination of production in the United States.

## Foreign Trade

Total imports increased significantly for the second year in a row—25% by weight and 26% by value in 1998 and 46% by weight and 32% by value in 1997 (table 4). Increases came from all major suppliers except Peru, where problems with shipping were caused by the weather phenomenon "El Niño" (Metal Bulletin, 1998b). Of the 13 supplying countries, the 5 largest, in descending order—Mexico, Belgium, the United Kingdom, China, and Canada—accounted for 95% of the total.

Exports increased 19% by weight but decreased 5% by value in 1998 (table 3), but they remained small (about 9% by weight and 12% by value) compared to imports.

## World Review

World supply appeared adequate for 1998 (table 5). A major factor was the large amount of bismuth available from China at low prices (Mining Journal, 1998a).

Usually, bismuth is recovered as a byproduct of lead or tungsten production. The world's only significant potential source where bismuth could be the principal product is the Tasna Mine in Bolivia, which was closed in 1985. New partners at Tasna, Corriente Resources, Inc. of Vancouver, and the state mining corporation, COMIBOL, continued to make plans for the reopening of the mine, but low prices delayed their implementation. Corriente planned to make coproducts of all the metals obtained from Tasna, including copper, gold, and tungsten. Mineral credits other than for bismuth have been estimated to be about 40% of the projected output (Metal Bulletin, 1998c).

Two Canadian companies, Noranda Inc. and Teck Corp., purchased 50% of the Antamina copper-zinc project in Peru. This property, which could become the world's seventh largest copper and third largest zinc project, was expected to produce lead at the rate of 7,000 metric tons per year. This lead contained some bismuth (Metal Bulletin, 1998d).

## Current Research and Technology

Researchers using bismuth concentrates from the Nico deposit in the Northwest Territories, Canada, obtained 99% recovery for bismuth and copper by using a ferric chloride leach. These results indicated that all the economic metals within the deposit can be recovered on site by using hydrometallurgy, thus eliminating the need for a smelter. Other metals contained in the deposit were cobalt and gold (Metal Bulletin, 1998a).

Research and development in the field of lubricants has resulted in the formulation of new products that provide protection for metal parts under extreme pressure (EP) conditions, such as may be found in mining operations. Manufacturers of oil and grease found that making additions to the base fluid was more cost effective than to attempt to change the chemistry of the base fluid itself. EP additives prevent galling, scoring, welding, and other metallic failure modes caused by high loads. The most effective of these additions typically contained a heavy metal (for example, lead) combined to make a unique compound called dialkythiocarbamate (DTC). Lead DTC, which has been used for almost 40 years, yields excellent EP performance, but concern about its environmental and occupational impacts has been expressed. In some formulations, lead has been replaced by the "less toxic" antimony. New research has taken this a step farther by using bismuth, which is heavy but nontoxic, as indicated by all the years of stomach relief applications. Bismuth DTC has EP properties similar to those of lead DTC, is easy to make, and is available now as a patented formulation for experimental use (Karol, 1998).

## Outlook

The long-range outlook for bismuth indicates that demand will probably increase, especially as development and implementation continue not only in the area of nontoxic replacements for lead, but also in new applications. Demand, however, could be described as steady rather than growing in recent years. Since bismuth is most often a byproduct of lead, a rapid increase in supply is unlikely, especially because the total production of lead remains fairly flat, with a large and increasing fraction of lead demand satisfied by recycling. In spite of this, there never appears to be a physical shortage, even with the loss of U.S. production. The ability of China to respond to any probable increase in demand is a very important factor in keeping the market stable (Mining Journal, 1998b).

Significant increases in demand for new applications, except for shot in waterfowl hunting, apparently await further impetus. In summary, anticipated large increases in demand are not occurring as soon as had been expected. The fact that supply has been adequate for any increase in demand to date has tended to stabilize the bismuth market.

## References Cited

- Goldstein, Laura, 1998, Kiss cold sores goodbye with Pepto-Bismol: *Prevention*, v. 50, no. 7, p. 164.  
Karol, T.J., 1998, Bismuth in lubrication: *Bulletin of the Bismuth Institute*, no. 71, p. 1-2.  
Metal Bulletin, 1998a, Bismuth leaching yields success at Nico: *Metal Bulletin*,

- no. 8269, April 16, p. 10.  
——— 1998b, Bismuth market strengthens on consumer buying: *Metal Bulletin*, no. 8263, March 23, p. 10.  
——— 1998c, Corriente Resources rethinks Tasna bismuth development: *Metal Bulletin*, no. 8335, December 14, p. 7.  
——— 1998d, Noranda and Teck take Inmet's stake in Antamina: *Metal Bulletin*, no. 8277, May 14, p. 5.  
——— 1998e, Tin has strong future as lead replacement: *Metal Bulletin*, no. 8279, May 21, p. 6.  
Mining Journal, 1998a, Minor metals in July: *Mining Journal*, v. 331, no. 8492, August 7, p. 111.  
——— 1998b, Minor metals in September: *Mining Journal*, v. 331, no. 8501, October 9, p. 283.

## SOURCES OF INFORMATION

### U.S. Geological Survey Publications

- Bismuth. Ch. in *Mineral Commodity Summaries*, annual.<sup>1</sup>  
Bismuth. Ch. in *Minerals Yearbook*, annual.<sup>1</sup>  
Bismuth. Ch. in *United States mineral resources*, U.S. Geological Survey Professional Paper 820, 1973.  
Bismuth. *Mineral Industry Surveys*, quarterly.<sup>1</sup>

### Other

- Bismuth. Ch. in *Mineral facts and problems*, U.S. Bureau of Mines Bulletin 675, 1985.

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<sup>1</sup>Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1  
SALIENT BISMUTH STATISTICS 1/

(Metric tons)

	1994	1995	1996	1997	1998
<b>United States:</b>					
Consumption	1,490	2,150	1,520	1,530	1,990
Exports 2/	160	261	151	206	245
Imports for consumption	1,660	1,450	1,490	2,170	2,720
Price, average, domestic dealer, per pound	\$3.25	\$3.85	\$3.65	\$3.50	\$3.60
Stocks, December 31, consumer	402	390	122	213	175
<b>World:</b>					
Mine production, metal content 3/	3,410 r/	3,440 r/	3,610	4,480 r/	4,020 e/
Refinery production 3/	4,180	3,840 r/	4,180 r/	4,070 r/	3,780 e/

e/ Estimated. Revised.

1/ Data are rounded to three significant digits.

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

3/ Excludes the United States.

TABLE 2  
BISMUTH METAL CONSUMED IN THE UNITED STATES, BY USE 1/

(Metric tons)

Use	1997	1998
Chemicals 2/	655	884
Bismuth alloys	593	741
Metallurgical additives	252	335
Other	31	32
Total	1,530	1,990

1/ Data are rounded to three significant digits; may not add to totals shown.

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

TABLE 3  
U.S. EXPORTS OF BISMUTH METAL, ALLOYS, AND WASTE AND SCRAP, BY COUNTRY 1/

Country	1997		1998	
	Quantity (kilograms, metal content)	Value (thousands)	Quantity (kilograms, metal content)	Value (thousands)
Argentina	960	\$10	40	\$3
Australia	21	10	17	6
Belgium	36,900	81	84,200	430
Bermuda	180	10	--	--
Canada	120,000	1,760	80,000	1,070
China	684	6	1,310	42
Dominican Republic	1,290	45	2,400	98
Finland	--	--	1,140	20
France	2,450	19	--	--
Germany	1,300	95	32,100	294
Grenada	717	6	--	--
Hong Kong	166	14	--	--
Ireland	1,500	33	--	--
Israel	2,230	19	696	16
Korea, Republic of	--	--	150	26
Malaysia	103	3	5,970	116
Mexico	218	19	5,190	44
Netherlands	4,980	44	--	--
Philippines	--	--	210	4
Saudi Arabia	--	--	50	4
Singapore	4,900	79	5,470	18
Taiwan	72	11	1,610	32
United Kingdom	27,500	250	24,300	159
Total	206,000	2,510	245,000	2,380

1/ Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 4  
U.S. IMPORTS FOR CONSUMPTION OF METALLIC BISMUTH, BY COUNTRY 1/

Country	1997		1998	
	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Belgium	691,000	\$5,320	739,000	\$5,880
Canada	99,400	789	155,000	1,230
China	161,000	1,160	385,000	2,830
France	32	10	--	--
Germany	114	21	45,400	201
Italy	--	--	850	41
Japan	600	25	1,200	46
Macao	20,000	128	--	--
Malaysia	4,270	31	--	--
Mexico	601,000	3,870	807,000	5,170
Netherlands	161	7	295	17
Peru	163,000	1,150	68,800	518
Russia	--	--	19,200	145
Spain	100	1	400	6
Switzerland	19	3	--	--
Taiwan	--	--	1,440	9
United Kingdom	425,000	2,720	492,000	3,090
Total	2,170,000	15,200	2,720,000	19,200

1/ Data are rounded to three significant digits; may not add to totals shown.

Source: Bureau of the Census.

TABLE 5  
BISMUTH: WORLD MINE AND REFINERY PRODUCTION, BY COUNTRY 1/ 2/

(Metric tons)

Country	Mine					Refinery				
	1994	1995	1996	1997	1998 e/	1994	1995	1996	1997	1998 e/
Belgium e/	--	--	--	--	--	900	800	800	800	700
Bolivia	--	121	348	684 r/	650	36	19	28	55 r/	50
Bulgaria e/	40	40	40	40	40	40	40	40	40	40
Canada 3/	129	187	150	183	180	--	--	--	--	--
China e/	610	740	610	550 r/	600	850	800	750 r/	760 r/	750
Italy e/	--	--	--	--	--	5	5	5	5	5
Japan 4/	152 e/	177 e/	169 e/	165 r/	150	505	591	562	550	500
Kazakhstan e/	115 r/	165 r/	115	115	115	85 r/ 5/	33 r/ 5/	50 r/	50 r/	50
Mexico 6/	1,047	995	1,070	1,642	1,204 5/	836	924	957	990	900
Peru	1,210	900	1,000 e/	1,000 e/	1,000	877	581	939	774 r/	744 5/
Romania e/	40	40	40	40	40	35	35	35	35	35
Russia e/	40	50	50	50	35	9	10	10	10	7
Serbia and Montenegro e/	5	5	5	5	5	(7/) 5/	(7/) 5/	(7/)	(7/)	(7/)
Tajikistan e/	12	11	5	5	5	--	--	--	--	--
United States	W	W	W	W	W	W	W	W	W	--
Uzbekistan e/	10	10	11	--	--	--	--	--	--	--
Total	3,410 r/	3,440 r/	3,610	4,480 r/	4,020	4,180	3,840 r/	4,180 r/	4,070 r/	3,780

e/ Estimated. r/ Revised. W Withheld to avoid disclosing company proprietary data; excluded from "Total."

1/ World totals and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through May 11, 1998. Bismuth is produced primarily as a byproduct of other metals, mostly lead; Bolivia is the sole producer of primary bismuth.

3/ Figures listed under mine output are the metal content of concentrates produced.

4/ Reported figure.

5/ Mine output figures have been estimated based on reported metal output figures.

6/ Refined metal includes Bi content of imported smelter products.

7/ Less than 500 kilograms. Production in kilograms: 1994--88; 1995--86; 1996--100 (estimated); and 1997-98--not available.