BISMUTH

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U.S. bismuth consumption increased 3% during 1999, compared with 1998. Consumption of bismuth alloys and metallurgical additives increased, and that of chemicals and pharmaceuticals decreased. In 1999, 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. The last stocks of bismuth held in the National Defense Stockpile (NDS) were sold that same year. The largest foreign producers of refined bismuth are Belgium, China, Mexico, and Peru.

Domestically, about 42% of bismuth was used in pharmaceuticals and chemicals, 40% in bismuth alloys, 16.5% as metallurgical additives, and 1.5% for other uses (table 2). 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 for waterfowl hunting. Another newly developed use was in galvanizing to improve the drainage characteristics of galvanizing alloys. Zinc-bismuth alloys have the same drainage properties as zinc-lead alloys. Zinc-bismuth-lead alloys have provided significant improvements in drainage (Gagné, 1998).

In 1999, the average New York dealer price for bismuth increased from $3.60 per pound to $3.85 per pound (table 1). This increase continued the price rise in 1998 that followed declines in 1997 and 1996. The value of bismuth consumed domestically in 1999 was about $17.4 million.

Legislation and Government Programs

The Defense Logistics Agency, which administers the NDS, sold the final 85 metric tons of bismuth in the stockpile on November 4, 1997.

The conversion to plumbing alloys that contain bismuth rather than lead is driven by 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 U.S. producer of primary bismuth, ceased production on June 30, 1997. Some domestic firms continued to recover bismuth from fusible alloy scrap in 1999, but secondary production data were not available. Secondary production was estimated to be 5% or less of the domestic supply during the year.

Consumption

Domestic bismuth consumption data are collected by the U.S. Geological Survey through a voluntary survey. Of the 40 firms that received the consumption survey form in 1999, 75% responded. The respondents accounted for an estimated 75% 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 in 1999 was estimated to be 2,050 metric tons, a 3% increase from 1998 (table 1). There was a moderate increase in bismuth alloys and a small increase in metallurgical additives in 1999, accompanied by small decreases in chemical and pharmaceutical uses. Chemical uses, formerly composing most of the bismuth consumed, accounted for less than one-half of the bismuth used domestically for the third successive year. The best known chemical use is that of bismuth subsalicylate, the active ingredient in over-the-counter stomach remedies. Other bismuth pharmaceuticals are used to treat burns, intestinal disorders, and stomach ulcers; veterinary applications were important as well. Bismuth nitrate is the initial material used for the production of most other bismuth compounds. Other bismuth chemical and compound uses include applications ranging from superconductors to some pearlescent pigments in cosmetics and paints.

Bismuth metal use primarily is categorized as bismuth alloys and metallurgical additives (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 and other articles 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 is added in small amounts to aluminum, copper, and steel alloys to improve machinability. It is also added to malleable iron to prevent the formation of graphite flakes.

In addition, there is considerable interest 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 as well as steel in shotgun pellets. In fact, one area of steady increase since 1994 has been the use of bismuth alloy cartridges for waterfowl hunting; the alloy used has been 97% bismuth and 3% tin.

Bismuth also 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. The use of bismuth (often in combination with selenium) to replace lead in plumbing brasses has reached the production stage. Although this strategy appeared to be the most promising metallurgical approach to meeting more stringent tapwater standards in the United States, increases in bismuth consumption for this application remained sluggish in 1999.

There has been an effort to replace other lead additions as well. For example, bismuth has been a substitute for 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. Nevertheless, although bismuth has been successful in replacing lead in various applications, it is now being challenged as a lead substitute by tungsten and tin (Cusack, 1999).

Prices

The domestic dealer price for commercially pure bismuth, published by Platt's Metals Week, averaged about $3.85 per pound in 1999, representing a 7% ($0.25) increase after a 3% increase in 1998 and decreases of 4% in 1997 and 5% in 1996 (table 1). The price was $3.15 per pound at the beginning of 1999, after decreasing during the last three quarters of 1998 from a $4.08-per-pound high earlier in the year. The price rose slowly during the first half of 1999, reaching $3.75 per pound at the end of May. During June, the price began to decline, reaching $3.65 in July. Then it increased steadily to $4.65 in October, but declined again to $4.30 per pound by the end of the year. The increases appeared to be due to steady demand and concern about decreases in production in Mexico and Peru. Whenever more Chinese bismuth was available to the market, the price stabilized, and sometimes decreased moderately.

Foreign Trade

Total bismuth imports decreased significantly—22% by weight in 1999 (table 4). Large decreases in the amounts received from Mexico (66%) and Peru (90%) were not matched by a 44% increase from China. Apparently consumers were able to meet demand for their products by using stocks.

Exports increased 5% by weight but decreased 15% by value in 1999 (table 3), but they remained small (about 12% by weight and 13% by value) compared to imports. Mexico, the country with the largest decrease in exports to the United States also had the largest increase (nearly five times as much by weight for 1999 compared with 1998) in imports from the United States.

World Review

World refinery production decreased slightly but world supply appeared adequate for 1999 (table 5). A major factor continued to be the large amount of bismuth available from China at low prices (Mining Journal, 1999b, c). Production was lower in Peru owing to a switch from using high bismuth-bearing concentrates to using high silver and gold concentrates (Mining Journal, 1999d). Output also declined in Mexico owing to renovations needed to meet pollution regulations (Mining Journal, 1999e).

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, Corpación Minera de Bolivia (COMIBOL), continued to make plans for the reopening of the mine, but low prices delayed their implementation. While originally placing the main emphasis on bismuth, 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 (Mining Journal, 1999a).

Russia included bismuth in a list of metals to be covered by a 5% export tax. Originally set to cover only copper and nickel, the new tariff now includes several minor metals. One American trader indicated that the tariff would have little impact because Russia is not a major producer (American Metal Market, 1999). Perhaps more importantly, Russia is not a significant supplier of bismuth to the United States.

Current Research and Technology

In Japan, new efforts to develop high performance bismuth-antimony semiconductors and to improve production efficiency by using sintering rather than fusion for their manufacture were announced at the Tohoku Industrial Science and Technology Research Institute in 1999 (Roskill's Letter from Japan, 1999b).

Continuing 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. 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 (commonly lead) combined to make a special 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 health 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 nearly as heavy as lead but nontoxic, as confirmed by many years of stomach relief applications. Bismuth DTC has EP properties similar to those of lead DTC, is easy to produce, and is available as a patented formulation for experimental use (Karol, 1998).

The NewMerc Company, Blacksburg, VA, has developed a nontoxic, electrically conductive liquid metal alloy which includes bismuth. It is intended as a safe alternative to mercury in certain applications (Metal Bulletin Monthly, 1999).

Outlook

Although demand is not expected to increase significantly in the immediate future, the long-range outlook for bismuth indicates that demand will probably grow, especially in new applications and as the development of nontoxic substitutes for lead continues. The use of bismuth in plumbing fixtures and shot for ammunition has begun to increase in the United States and in Europe. In Japan and elsewhere, however, this increase has been very slow because the applicable environmental regulations are less stringent (Roskill's Letter from Japan, 1999a). Bismuth is most often a byproduct of lead; a significant increase in domestic supply, therefore, is unlikely, especially because total U.S. production of lead will remain relatively stable with a large and increasing fraction of lead demand satisfied by recycling. Nevertheless, a global shortage of bismuth is not anticipated. Despite any increase in world demand, Chinese supplies are expected to help keep the bismuth market stable (Mining Journal, 1999c).

Level demand in the bismuth market has been viewed by some Western producers as "lacklustre performance over the past few years" particularly as China's entry into the market restrained price increases. However, at least one market observer believes that low prices are due to deflationary economics in the 1990's and reductions in state stockpiles since the end of the Cold War (Carnac, 1999). Moreover, it should be noted that, despite restraints on price increases by Chinese bismuth exports in the next few years, these supplies also will increase the availability of bismuth for new applications.

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GENERAL SOURCES OF INFORMATION

U.S. Geological Survey Publications

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Bismuth. Ch. in Minerals Yearbook, annual.[1]
Bismuth. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
Bismuth. Mineral Industry Surveys, quarterly.[1]

Other

Bismuth. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.

[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
SALIENT BISMUTH STATISTICS 1/

(Metric tons)

	1995	1996	1997	1998	1999
United States:					
Consumption	2,150	1,520	1,530	1,990	2,050
Exports 2/	261	151	206	245	257
Imports for consumption	1,450	1,490	2,170	2,720	2,110
Price, average, domestic dealer, per pound	$3.85	$3.65	$3.50	$3.60	$3.85
Stocks, December 31: Consumer	390	122	213	175	121
World:					
Mine production (metal content) 3/	3,430 r/	3,430 r/	4,150 r/	3,330 r/	3,620 e/
Refinery production 3/	3,840	4,180	4,070	4,080 r/	4,000 e/

e/ Estimated. r/ Revised.
1/ Data are rounded to no more than 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	1998	1999
Chemicals 2/	884	855
Bismuth alloys	741	823
Metallurgical additives	335	340
Other	32	31
Total	1,990	2,050

1/ Data are rounded to no more than 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	1998 Quantity (kilograms, metal content)	1998 Value (thousands)	1999 Quantity (kilograms, metal content)	1999 Value (thousands)
Argentina	40	$3	--	--
Australia	17	6	41	$9
Belgium	84,200	430	83,400	453
Canada	80,000	1,070	87,700	732
China	1,310	42	--	--
Dominican Republic	2,400	98	1,240	67
Finland	1,140	20	--	--
Germany	32,100	294	19,000	168
Hong Kong	--	--	7,900	100
Ireland	--	--	94	5
Israel	696	16	--	--
Korea, Republic of	150	26	--	--
Malaysia	5,970	116	919	3
Mexico	5,190	44	29,900	289
New Zealand	--	--	50	5
Philippines	210	4	--	--
Saudi Arabia	50	4	--	--
Singapore	5,470	18	1,240	22
Taiwan	1,610	32	46	7
Trinidad and Tobago	--	--	15,900	46
United Kingdom	24,300	159	8,230	84
Venezuela	--	--	947	10
Total	245,000	2,380	257,000	2,000

-- Zero.
1/ Data are rounded to no more than 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	1998 Quantity (kilograms)	1998 Value (thousands)	1999 Quantity (kilograms)	1999 Value (thousands)
Bahamas, The	--	--	735	$8
Belgium	739,000	$5,880	742,000	5,790
Canada	155,000	1,230	108,000	827
China	385,000	2,830	556,000	4,080
Germany	45,400	201	1,490	64
Italy	850	41	400	19
Japan	1,200	46	3,260	165
Mexico	807,000	5,170	277,000	1,880
Netherlands	295	17	19,500	202
Peru	68,800	518	6,810	60
Russia	19,200	145	--	--
Spain	400	6	200	2
Switzerland	--	--	86	3
Taiwan	1,440	9	--	--
United Kingdom	492,000	3,090	391,000	2,220
Total	2,720,000	19,200	2,110,000	15,300

-- Zero.
1/ Data are rounded to no more than 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 1995	Mine 1996	Mine 1997	Mine 1998	Mine 1999 e/	Refinery 1995	Refinery 1996	Refinery 1997	Refinery 1998	Refinery 1999 e/
Belgium e/	--	--	--	--	--	800	800	800	700	700
Bolivia	121	178 r/	350 r/	280 r/	255	19	28	55	44 r/	40
Bulgaria e/	40	40	40	40	40	40	40	40	40	40
Canada 3/	187	150	183	219 r/	311 p/	--	--	--	--	--
China e/	740	610	550	240 r/	400	800	750	760	820 r/	1,300
Italy e/	--	--	--	--	--	5	5	5	5	5
Japan 4/	177 e/	169 e/	165	144 r/	135	591	562	550	479 r/	450
Kazakhstan e/	165	115	115	115	130	33 5/	50	50	50	55
Mexico 6/	995	1,070	1,642	1,204	1,250	924	957	990	1,030 r/	600
Peru	900	1,000 e/	1,000 e/	1,000 e/	1,000	581	939	774	868 r/	760
Romania e/	40	40	40	40	40	35	35	35	35	35
Russia e/	50	50	50	35	50	10	10	10	7	10
Serbia and Montenegro e/	5	5	5	5	2	(7/) 5/	(7/)	(7/)	(7/) 5/	(7/)
Tajikistan e/	11	5	5	5	5	--	--	--	--	--
United States	W	W	W	W	W	W	W	W	--	--
Uzbekistan e/	-- r/	-- r/	--	--	--	--	--	--	--	--
Total	3,430 r/	3,430 r/	4,150 r/	3,330 r/	3,620	3,840	4,180	4,070	4,080 r/	4,000

e/ Estimated. p/ Preliminary. r/ Revised. W Withheld to avoid disclosing company proprietary data; not included in "Total." -- Zero.

1/ World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

2/ Table includes data available through May 11, 2000. 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/ Mine output figures have been estimated based on reported metal output figures.

5/ Reported figure.

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

7/ Less than 500 kilograms. Production in kilograms: 1995--86; 1996--100 (estimated); 1997-99--not available.