



# 2007 Minerals Yearbook

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## BISMUTH

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By James F. Carlin, Jr.

**Domestic survey data and tables were prepared by Lisa A. Mersdorf, statistical assistant, and the world production table was prepared by Linder Roberts, international data coordinator.**

Bismuth consumption in the United States was estimated to be 2,650 metric tons (t), an increase of 33% compared with that in 2006 (tables 1, 2). The estimated domestic consumption breakdown for bismuth for 2007 was 55% for chemical and pharmaceutical uses; 35% for metallurgical additives; 7% for alloys; and 3% for research and other uses (table 2).

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 2007, 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 2007 were China, Mexico, Belgium, and Peru, in descending order. 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.

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

The average annual dealer price for bismuth in 2007 increased to \$14.07 per pound, 179% more than that in 2006. Industry sources attributed the dramatic price increase to speculative investment fund buying.

The estimated value of bismuth consumed domestically was about \$82 million in 2007. That represents an increase of 257% compared with the value in 2006.

## Production

Domestic production of primary refined bismuth ceased in 1997. Some domestic firms continued to recover secondary bismuth from fusible alloy scrap in 2007, but secondary production data were not available. Secondary production was estimated to be less than 5% of domestic supply during the year.

## Consumption

The U.S. Geological Survey collects bismuth consumption data quarterly and annually. The amount of bismuth used by nonrespondents is estimated based on reports from prior years or on information from other sources. Accordingly, estimated bismuth consumption was about 2,650 t in 2007, a 33% decline from that in 2006 (table 1).

Consumption of bismuth in chemical uses (chemicals, cosmetics, and pharmaceuticals) in 2007 increased significantly by 121%, compared with the amount used in 2006. Metallurgical additives, normally the leading usage category and subject to weakness in industrial activity, experienced an 11%

decrease in consumption in 2007 compared with usage in 2006. The alloys category of use registered a 27% decline in tonnage compared with that of 2006.

Although it has the crystal structure of a semimetal, bismuth is often considered a metal. This crystal structure, along with several 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 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 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 1982. Although bismuth has successfully replaced 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. It is also added to malleable iron graphite flakes. These uses constitute the traditional metallurgical additives category.

## Price

In 2007, the average Platts Metals Week New York dealer price for bismuth rose sharply to \$14.07 per pound, an increase of 179% from the average price of \$5.04 per pound in 2006. The annual average price has experienced a steady and substantial rise starting in 2003.

The weekly price started 2007 at \$7.30 to \$7.80 per pound and ended the first quarter at \$10.50 to \$11.00 per pound; the second quarter saw prices rising steadily to end the quarter at \$18.00 to \$19.00 per pound; in the third quarter, prices evened out to end the quarter at \$15.25 to \$16.25 per pound; and prices in the fourth quarter generally declined to end the year at \$12.75 to \$13.75 per pound.

## Trade

U.S. exports of bismuth metal, alloys, and waste and scrap rose by 35% from those of 2006. Notable increases were recorded in exports to Belgium, Mexico, and the United Kingdom. Substantial decreases were noted for the Dominican Republic (table 3). Imports of metallic bismuth, by weight, increased by 34% compared with the prior year's figures (table 4). Bismuth imports, on a weight basis, were seven times greater than bismuth exports. The leading import source for the United States was the United Kingdom, followed closely by Belgium. Considerable increases in U.S. imports were observed for those from Germany and the United Kingdom. Notable decreases in U.S. imports were those from Hong Kong, Mexico, 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 known mine in the world that produces bismuth from bismuth ore, has been on standby since the mid-1990s, awaiting a sufficient and substantial 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 refinery production of bismuth remained the same as it was in 2006, at 15,000 t. China was the world's leading producer of refined bismuth with 77% of the world total, followed by Mexico with 8%, and Belgium with 5%.

Two of the major international producers of refined bismuth products agreed to merge their operations to become the world's leading refiner of bismuth metals. MCP Aramayo Ltd. (Farnham, United Kingdom) and Sidech S.A. (Tilly, Belgium) agreed to combine their operations under the aegis of a new organization called MCP Group S.A., with headquarters in Belgium. Both firms also produced other minor metals such as indium, gallium, selenium, and tellurium, but had long been dominant in bismuth production. The new organization will have production facilities in Belgium, China, France, Germany, the United Kingdom, and the United States (Platts Metals Week, 2007).

**Canada.**—Fortune Minerals Ltd. (London, Ontario) announced further progress with its 90% owned NICO gold-cobalt-bismuth project in the Northwest Territories. Metallurgical test work at SGS Lakefield Research Ltd. produced an upgraded bismuth (metal) bullion product from concentrate at the NICO project. Production of bismuth metal at the NICO site would significantly reduce transportation and treatment charges from a third-party bismuth smelter and may materially improve the economics for the NICO project. Two

process methods were evaluated during the current program. The one using ferric chloride leaching and iron cementation hydrometallurgical processing proved to be the most effective, with bismuth grades and recoveries sharply exceeding Fortune's expectations (Fortune Minerals Ltd., 2007).

Later in the year Fortune announced the startup of its \$3.8 million pilot plant at SGS Lakefield Research in Ontario for its NICO deposit. A total of 180 t of ore that was mined from the NICO deposit during 2006 and 2007, underground test mining programs were to be processed (Fortune Minerals Ltd., 2007).

**China.**—Hunan Shizhuyuan Nonferrous Metal Co., one of China's leading bismuth refiners, announced that it had only produced 40 t of bismuth in January instead of its usual 60 t, owing to difficulties in mining during the winter and the declining bismuth content in its ores. Hunan Shizhuyuan Nonferrous Metal started trial runs at its new concentrator, which was commissioned in the summer of 2007. As a result of this addition, Hunan's bismuth production was expected to rise by 17% in 2007 to 700 t. Hunan produced 600 t of bismuth in 2006, about 50 t lower than that in 2005, as falling grades and a tropical storm affected output. By midyear, the operation was producing bismuth at a rate of about 70 metric tons per month (t/mo), up from 40 t/mo in the first quarter of the year (Mining Journal, 2007).

Chenzhou Jinwang Enterprise Co., an important private smelter in central Hunan Province, producing 1,000 metric tons per year (t/yr) of bismuth, announced that it would be closed for most of February for maintenance (Mining Journal, 2007). Ganzhou Nonferrous Metal Co. announced plans to increase its bismuth metal output to about 1,000 t in 2007 from 600 t in 2006 (Platts Metals Week, 2007).

Seven bismuth producers in the country's major nonferrous metals production region of Chenzhou, Hunan Province, sought to create what would be the world's leading bismuth producer from mine sources. It was reported that Hunan Shizhuyuan Nonferrous Metal, the only state-owned company among the seven, could become the leading shareholder of the proposed new organization. It was thought that the new company would produce about 36,000 to 48,000 t/yr of bismuth. Producers in Chenzhou controlled about 40% of China's entire bismuth output. Chenzhou authorities reportedly were actively promoting the merger, as they wanted to consolidate their bismuth resources (American Metal Market, 2007).

The Government of China announced that it would reduce the value added tax (VAT) rebate from 15% to 5% for bismuth rolled products and for bismuth with a purity above 99.99% (Ryan's Notes, 2007).

**India.**—Sterlite Industries India Ltd. (Tami Nadu) announced plans to enter the bismuth market with the startup of two bismuth bisulfate production units by yearend 2007. The plants are in Tuticorin and Silvassa, each associated with existing Sterlite copper refineries. The new plants' combined production capacity was anticipated to be 250 to 300 t/yr of bismuth bisulfate, a raw material used in the production of bismuth that would eventually yield about 100 t/yr of refined bismuth. Current world production of bismuth bisulfate is estimated to be about 500 t/yr. Sterlite's project was one of three or four similar projects being developed by other copper producers

that have bought technology from Utah-based IBC Advanced Technologies, Inc. for the recovery of bismuth from the copper refinery circuit (Metal Bulletin, 2007).

## Outlook

Worldwide bismuth consumption appeared to be increasing by about 3% to 5% per year. Demand for bismuth in the steel sector, although relatively minor compared with that in other use sectors, appeared to be increasing. World consumption in the chemical industry 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 solder. This agreement is expected to increase the use of bismuth in solders. Several Japanese manufacturers of electronic and electric equipment are now using lead-free solders 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% by these moves, world bismuth consumption may increase by about 25% with a move to lead-free solders.

A material near-term increase in supplies of lead byproduct bismuth was unlikely because world production of lead from mine/refinery sources was expected to be relatively stable, and an increasing portion of lead demand was expected to be met by recycling. However, a global shortage of bismuth was not anticipated. In China, where bismuth is a byproduct of fluorspar, lead, tin, and tungsten processing, new technologies applied to these resources have increased world bismuth reserves. Chinese

supplies are expected to be able to keep the bismuth market stable.

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TABLE 1  
SALIENT BISMUTH STATISTICS<sup>1</sup>

|                                 |                   | 2003               | 2004               | 2005                | 2006                | 2007   |
|---------------------------------|-------------------|--------------------|--------------------|---------------------|---------------------|--------|
| United States:                  |                   |                    |                    |                     |                     |        |
| Consumption <sup>2</sup>        | metric tons       | 2,210 <sup>r</sup> | 1,880 <sup>r</sup> | 2,390 <sup>r</sup>  | 1,990 <sup>r</sup>  | 2,650  |
| Exports <sup>3</sup>            | do.               | 108                | 109                | 142                 | 311                 | 421    |
| Imports for consumption         | do.               | 2,320              | 1,990 <sup>r</sup> | 2,530               | 2,300               | 3,070  |
| Price, average, domestic dealer | dollars per pound | 2.87               | 3.35               | 3.91                | 5.04                | 14.07  |
| Stocks, December 31, consumer   | metric tons       | 172 <sup>r</sup>   | 167 <sup>r</sup>   | 175 <sup>r</sup>    | 110 <sup>r</sup>    | 130    |
| World production: <sup>6</sup>  |                   |                    |                    |                     |                     |        |
| Mine metal content <sup>4</sup> | do.               | 5,100              | 5,600              | 5,400               | 5,800 <sup>r</sup>  | 6,400  |
| Refinery                        | do.               | 8,700              | 15,000             | 14,000 <sup>r</sup> | 15,000 <sup>r</sup> | 15,000 |

<sup>6</sup>Estimated. <sup>r</sup>Revised. do. Ditto.

<sup>1</sup>Data are rounded to no more than three significant digits.

<sup>2</sup>Estimated, based on net imports.

<sup>3</sup>Comprises bismuth metal and the bismuth content of alloys and waste and scrap.

<sup>4</sup>Excludes the United States.

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

(Metric tons)

| Use                     | 2006 <sup>†</sup> | 2007  |
|-------------------------|-------------------|-------|
| Chemicals <sup>3</sup>  | 660               | 1,460 |
| Bismuth alloys          | 260               | 189   |
| Metallurgical additives | 1,050             | 935   |
| Other                   | 12                | 73    |
| Total                   | 1,990             | 2,650 |

<sup>†</sup>Revised.

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

<sup>2</sup>Estimated, based on net imports.

<sup>3</sup>Includes industrial and laboratory chemicals, cosmetics, and pharmaceuticals.

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

| Country              | 2006                                      |                      | 2007                                      |                      |
|----------------------|---|----------------------|---|----------------------|
|                      | Quantity<br>(kilograms,<br>metal content) | Value<br>(thousands) | Quantity<br>(kilograms,<br>metal content) | Value<br>(thousands) |
| Argentina            | 9,400                                     | \$89                 | 14,500                                    | \$134                |
| Australia            | 20  | 3                    | 338                                       | 6                    |
| Austria              | --  | --                   | 103                                       | 4                    |
| Belgium              | --  | --                   | 66,200                                    | 1,500                |
| Brazil               | 20  | 5                    | 3,750                                     | 37                   |
| Canada               | 72,100                                    | 910                  | 63,800                                    | 1,080                |
| Chile                | 916                                       | 17                   | --  | --                   |
| China                | --  | --                   | 3,880                                     | 77                   |
| Costa Rica           | --  | --                   | 818                                       | 7                    |
| Czech Republic       | --  | --                   | 1,320                                     | 20                   |
| Dominican Republic   | 42,200                                    | 423                  | 7,640                                     | 149                  |
| Egypt                | --  | --                   | 104                                       | 11                   |
| France               | 14,400                                    | 131                  | 16,900                                    | 161                  |
| Germany              | 210                                       | 14                   | 9,400                                     | 92                   |
| Honduras             | --  | --                   | 108                                       | 4                    |
| Hong Kong            | 5,740                                     | 56                   | 2,410                                     | 22                   |
| India                | 164                                       | 8                    | 533                                       | 18                   |
| Ireland              | 324                                       | 6                    | 314                                       | 13                   |
| Israel               | 2,000                                     | 18                   | 8,730                                     | 56                   |
| Italy                | --  | --                   | 36  | 3                    |
| Japan                | 15,000                                    | 340                  | 14,900                                    | 250                  |
| Korea, Republic of   | 309                                       | 20                   | --  | --                   |
| Malaysia             | --  | --                   | 100                                       | 5                    |
| Mexico               | 9,400                                     | 184                  | 31,700                                    | 362                  |
| Morocco              | 717                                       | 7                    | --  | --                   |
| Saudi Arabia         | 50  | 12                   | 27  | 6                    |
| Singapore            | 29,300                                    | 290                  | 30,200                                    | 291                  |
| Spain                | 115                                       | 3                    | --  | --                   |
| Sweden               | --  | --                   | 1,010                                     | 17                   |
| Taiwan               | 2,030                                     | 18                   | 638                                       | 6                    |
| Thailand             | 2,690                                     | 24                   | 3,240                                     | 29                   |
| United Arab Emirates | --  | --                   | 12,400                                    | 113                  |
| United Kingdom       | 6,050                                     | 67                   | 41,400                                    | 993                  |
| Vietnam              | 97,800                                    | 898                  | 84,700                                    | 770                  |
| Total                | 311,000                                   | 3,540                | 421,000                                   | 6,230                |

-- Zero.

<sup>1</sup>Data 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 COUNTRY<sup>1</sup>

| Country        | 2006                    |                      | 2007                    |                      |
|----------------|-------------------------|----------------------|-------------------------|----------------------|
|                | Quantity<br>(kilograms) | Value<br>(thousands) | Quantity<br>(kilograms) | Value<br>(thousands) |
| Bahamas, The   | 1,080                   | \$14                 | --                      | --                   |
| Belgium        | 876,000                 | 8,070                | 1,020,000               | \$17,600             |
| Canada         | 9,100                   | 106                  | 13,200                  | 202                  |
| China          | 356,000                 | 3,920                | 437,000                 | 9,950                |
| France         | 3                       | 6                    | 23,300                  | 799                  |
| Germany        | 295                     | 18                   | 52,800                  | 1,050                |
| Hong Kong      | 74,600                  | 747                  | 347                     | 139                  |
| Italy          | 380                     | 49                   | 277                     | 38                   |
| Mexico         | 552,000                 | 5,630                | 420,000                 | 13,600               |
| Netherlands    | 1,080                   | 26                   | 87                      | 19                   |
| Peru           | 17,600                  | 229                  | 3,710                   | 111                  |
| Spain          | 1,920                   | 28                   | 1                       | 2                    |
| Switzerland    | --                      | --                   | 775                     | 27                   |
| United Kingdom | 406,000                 | 3,100                | 1,110,000               | 14,500               |
| Total          | 2,300,000               | 21,900               | 3,070,000               | 58,000               |

-- Zero.

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

Source: U.S. Census Bureau.

TABLE 5  
BISMUTH: ESTIMATED WORLD MINE AND REFINERY PRODUCTION, BY COUNTRY<sup>1,2</sup>

(Metric tons)

| Country               | Mine               |                    |                  |                      |                    | Refinery           |                    |                     |                      |        |
|-----------------------|--------------------|--------------------|------------------|----------------------|--------------------|--------------------|--------------------|---------------------|----------------------|--------|
|                       | 2003               | 2004               | 2005             | 2006                 | 2007               | 2003               | 2004               | 2005                | 2006                 | 2007   |
| Belgium               | --                 | --                 | --               | --                   | --                 | 1,000              | 800                | 800                 | 800                  | 800    |
| Bolivia               | 72 <sup>3</sup>    | 62 <sup>3</sup>    | 44 <sup>3</sup>  | 82 <sup>r,3</sup>    | 155                | 51 <sup>3</sup>    | 32 <sup>3</sup>    | -- <sup>3</sup>     | 40 <sup>r</sup>      | 80     |
| Bulgaria              | 40                 | 40                 | 40               | 45 <sup>r</sup>      | 45 <sup>r</sup>    | 40 <sup>3</sup>    | 35 <sup>3</sup>    | 35                  | 35                   | 35     |
| Canada <sup>4</sup>   | 145                | 185                | 185              | 214 <sup>r,3</sup>   | 145 <sup>p</sup>   | 250                | 250                | 250                 | 250                  | 200    |
| China                 | 2,500              | 3,000              | 3,000            | 3,000                | 3,500              | 5,000              | 11,700             | 10,600 <sup>r</sup> | 11,800 <sup>r</sup>  | 11,500 |
| Italy                 | --                 | --                 | --               | --                   | --                 | 5                  | 5                  | 5                   | 5                    | 5      |
| Japan <sup>5</sup>    | --                 | --                 | --               | --                   | --                 | 513                | 522                | 463 <sup>3</sup>    | 425 <sup>r,3</sup>   | 420    |
| Kazakhstan            | 150                | 150                | 140              | 140                  | 145                | 130                | 130                | 120                 | 115                  | 120    |
| Mexico                | 1,064 <sup>3</sup> | 1,064 <sup>3</sup> | 970 <sup>3</sup> | 1,186 <sup>r,3</sup> | 1,200              | 1,064 <sup>3</sup> | 1,064 <sup>3</sup> | 970 <sup>3</sup>    | 1,186 <sup>r,3</sup> | 1,200  |
| Peru                  | 1,000              | 1,000              | 952 <sup>3</sup> | 1,081 <sup>r,3</sup> | 1,114 <sup>3</sup> | 600                | 600                | 600                 | 600                  | 600    |
| Romania               | 40                 | 40                 | 40               | 40                   | 40                 | 35                 | 35                 | 35                  | 30                   | 30     |
| Russia                | 50                 | 50                 | 50               | 55                   | 55                 | 10                 | 10                 | 10                  | 11                   | 12     |
| Serbia and Montenegro | -- <sup>r</sup>    | --                 | --               | --                   | --                 | --                 | --                 | --                  | --                   | --     |
| Total <sup>6</sup>    | 5,100              | 5,600              | 5,400            | 5,800 <sup>r</sup>   | 6,400              | 8,700              | 15,000             | 14,000 <sup>r</sup> | 15,000 <sup>r</sup>  | 15,000 |

<sup>p</sup>Preliminary. <sup>r</sup>Revised. -- Zero.

<sup>1</sup>Estimated data are rounded to no more than three significant digits.

<sup>2</sup>Table includes data available through April 4, 2008. Bismuth is produced primarily as a byproduct of other metals, mainly lead and tungsten.

<sup>3</sup>Reported figure.

<sup>4</sup>Figures listed under mine output are the metal content of concentrates produced, according to Natural Resources Canada, 2004–05.

<sup>5</sup>Mine output figures have been estimated to be 5% of reported metal output figures.

<sup>6</sup>World totals are rounded to no more than two significant digits.