

4. PRODUCTION, IMPORT, USE, AND DISPOSAL

4.1 PRODUCTION

Antimony, while not abundant, occurs in over 100 minerals; the more important of these are sulfides and, to a lesser extent, oxides of Sb(III), and combinations with lead, copper, and silver. Stibnite (Sb_2S_3) is the predominant ore, followed in importance by valentinite (Sb_2O_3), senarmontite (Sb_2O_3), stibiconite ($\text{Sb}_2\text{O}_4 \cdot \text{H}_2\text{O}$), bindheimite ($\text{Pb}_2\text{Sb}_2\text{O}_7 \cdot n\text{H}_2\text{O}$), kermesite ($\text{Sb}_2\text{S}_2\text{O}$), tetrahedrite ($\text{Cu}_2\text{Sb}_2\text{O}_7$), and jamesonite ($2\text{PbS} \cdot \text{Sb}_2\text{S}_3$). It also occurs uncombined as the metal (Herbst et al. 1985; Miller 1973). The antimony content of commercial ores ranges from 5% to 60% (Carapella 1978). The world's largest concentrations of antimony are found in China, Bolivia, U.S.S.R., Republic of South Africa, and Mexico (Miller 1973).

Between 1977 and 1984, the amount of antimony mined in the United States ranged from 311 to 760 metric tons (Llewellyn 1988; Plunkert 1982). The low of 311 metric tons occurred in 1980, and was the result of an 8-month work stoppage at the Sunshine Mine in the Coeur d'Alene district of Idaho. Data for 1985, 1986, and 1988 were withheld to avoid disclosing proprietary company data (Anonymous 1989a, 1989b; Llewellyn 1988). This reflects the fact that there were two or fewer active antimony mines in the United States. In 1987, the Sunshine Mine was closed, and there was no antimony mined in the United States. In recent years, the principal domestic ore producers have been the Sunshine Mining Company in Idaho and the United States Antimony Corporation in Montana. The Sunshine Mining Company principally mines tetrahedrite in conjunction with silver mining, and the United States Antimony Corporation principally mines stibnite. Antimony is also produced as a byproduct of the smelting of primary lead ores.

The primary antimony output from smelters has generally been rising in recent years; smelter outputs were 14,922, 16,309, 18,795, and 18,692 metric tons in 1985, 1986, 1987, and 1988, compared with 11,644 metric tons in 1977 (Anonymous 1989a; Llewellyn 1988; Plunkert 1982). According to the U.S. Bureau of Mines, nine companies produced primary antimony metal and metal oxide products in the United States in 1987. These were ASARCO Incorporated, Omaha, Nebraska; Amspec Chemical Corp., Gloucester City, New Jersey; Anzon America, Laredo, Texas; Chemet Co., Moscow, Tennessee; Laurel Industries Inc., La Porte, Texas; McGean Chemical Co., Inc., Cleveland, Ohio; M&T Chemicals Inc., Baltimore, Maryland; Sunshine Mining Co., Kellogg, Idaho; and U.S. Antimony Corp, Thompson Falls, Montana (Llewellyn 1988). Most of the primary antimony generated in the United States was generated as the oxide. In 1985 and 1986, 13,969 and 15,898 metric tons of antimony oxide were produced, compared with 855 and 343 metric tons of metal, respectively. In 1987 and 1988, 18,758 and 18,226 metric tons of the oxide were produced, respectively; production figures for the metal were withheld to maintain business confidentiality (U.S. Bureau of Mines 1989a). In 1988, U.S. primary antimony consumption was 12,060 metric tons, of which 2,121 metric tons were metal, 9,432 metric tons were oxide, and 42 metric tons were sulfide (U.S. Bureau of

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Mines 1989a). Consumption trends have generally paralleled those of production. Table 4-1 lists the number of facilities in each state that produced, imported, processed, or used antimony and its compounds in 1987, according to reports made to EPA under requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 and subsequently published in the Toxic Chemical Release Inventory (TRI). Companies are required to report if they produced, imported, or processed 75,000 or more pounds of antimony and its compounds or used more than 10,000 pounds. Also included in Table 4-1 is the maximum amount of antimony and its compounds these facilities have on site and whether the antimony is produced, processed, or used at the site. The quality of the TRI data must be viewed with caution since 1987 data represent first-time, incomplete reporting by these facilities. Not all facilities that should have reported have done so.

Almost as much antimony is produced from scrap as from ore. Antimony produced from secondary sources is primarily derived from "old scrap," generally consisting of lead battery plates, type metal, and bearing metal. "New scrap," which is derived from drosses and scrap generated during fabrication, constituted 8.6% of the secondary antimony in 1987 (Llewellyn 1988). Secondary antimony is chiefly consumed as antimonial lead; a small percentage goes into the production of other lead- and tin-based alloys. Secondary antimony production has stabilized and recovered slightly after a long decline; it was 27,780 metric tons in 1977, 12,886 metric tons in 1983, and 13,635, 14,082, 15,189, and 16,172 metric tons in 1985, 1986, 1987, and 1988, respectively (U.S. Bureau of Mines.1989a; Llewellyn 1988; Plunkert 1982).

The method of treating antimony ore after mining depends on the type of ore and its antimony content. High grade (45-60%) sulfide ore that is free from lead and arsenic can be extracted by melting, a technique known as liquation. In this process, the ore is heated to 550-660°C in a crucible or reverberatory furnace in a reducing atmosphere. High-grade sulfide **ores** can also be reduced to the metal by iron precipitation, a technique in which the ore is heated with iron scrap, which replaces the antimony. High-grade oxide ores are reduced with charcoal in a reverberatory furnace. An alkaline flux is used to reduce volatilization losses, which may be as high as 12-20%. The method of choice for low-grade (less than 20%) sulfide ores is volatilizing roasting. In this process, the ore is heated to about 500°C, and the amount of oxygen is controlled, so that the antimony trioxide formed is volatilized and then recondensed. Intermediate-grade sulfide or oxide ores are generally handled by smelting (Carapella 1978; Herbst et al. 1985). The impure metal may be refined by pyrometallurgical techniques or electrolysis. For further details on antimony mining, ore processing, recovery, and refining, see Carapella (1978) or Herbst et al. (1985).

Antimony trioxide is produced by oxidizing antimony sulfide ore or antimony metal in air at 600-800°C (Avento and Touval 1980).

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TABLE 4-1. Facilities That Manufacture, Process, or Use Antimony and Compounds^a

State ^b	No. of facilities	Range of maximum amounts on site in thousands of pounds ^c	Activities and uses ^d
AL	5	10-9,999	2, 3, 7, 8
AR	3	1-999	3, 8, 9, 13
AZ	3	1-999	1, 2, 3, 4, 5, 6, 7, 9
CA	16 (1) ^e	0-999	1, 2, 3, 4, 7, 8, 9, 12
CO	2	10-99	1, 2, 4, 7, 8, 9
CT	5	10-999	1, 2, 3, 4, 7, 8, 9
DE	1	0.1-0.9	2, 9
FL	3 (1) ^e	1-9	3, 8, 11, 13
GA	8	0.1-99	1, 3, 4, 7, 8, 9
ID	3	1-9,999	1, 5, 8, 9, 12
IL	11 (1) ^e	1-999	2, 3, 7, 8, 9, 10, 11
IN	12	0.1-999	8, 9, 11
KS	4	10-99	8, 11
KY	12	0-9,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 11
LA	8 (1) ^e	0.1-999	7, 8, 9, 10, 11
MA	10 (1) ^e	1-999	1, 2, 3, 4, 7, 8, 9
MD	4	1-9,999	1, 2, 3, 4, 7, 8
MI	7	1-999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
	13		
MN	5	0-99	6, 8, 9
MO	8 (1) ^e	1-499,999	1, 2, 3, 4, 5, 7, 8, 9
MS	5 (1) ^e	0-99	8, 9
MT	1	10,000-49,999	1, 2, 3, 4, 7
NC	9	0-999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
	13		
NE	3	1-9,999	1, 2, 3, 4, 5, 7, 8, 9
NJ	22 (3) ^e	0.1-999	2, 3, 4, 6, 7, 8, 9, 10, 11

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TABLE 4-1 (Continued)

State ^b	No. of facilities	Range of maximum amounts on site in thousands of pounds ^c	Activities and uses ^d
NM	1	10-99	8, 9
NY	8	0.1-49,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
OH	34 (2) ^e	1-9,999	1, 2, 3, 4, 7, 8, 9, 10, 13
OK	4	0.1-99	2, 6, 8, 9, 11
OR	1	10-99	7, 9
PA	21	0.1-999	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12
RI	2	0.1-99	8, 9
SC	12	0.1-99	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
	12		
TN	7	10-999	1, 2, 6, 8, 9, 13
TX	24 (1) ^e	1-49,999	1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12
VA	4	1-99	3, 8, 9
VT	4	1-99	8, 9, 12
WA	2 (1) ^e	10-99	9, 11
WI	9	1-999	3, 7, 8, 9
WV	2	10-999	8, 9, 11

^aTRI 1989^bPost office state abbreviations^cData in TRI are maximum amounts on site at each facility.^dActivities/Uses:

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|-------------------------------|----------------------------------|
| 1. produce | 8. as a formulation component |
| 2. import | 9. as an article component |
| 3. for on-site use/processing | 10. for repackaging only |
| 4. for sale/distribution | 11. as a chemical processing aid |
| 5. as a byproduct | 12. as a manufacturing aid |
| 6. as an impurity | 13. ancillary or other use |
| 7. as a reactant | |

^eNumber of facilities reporting "no data" regarding maximum amount of the substance on site.

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4.2 IMPORT/EXPORT

The United States is not self-sufficient in antimony and depends heavily on imports of both ore and metal. In 1987 and 1988, 24,248 and 30,027 metric tons of antimony, respectively, were imported into the United States for consumption. Of this, 55.3% was as the metal, 31.9% as the oxide, 12.4% as ore and concentrate, and 0.4% as the sulfide in 1988 (U.S. Bureau of Mines 1989a). The respective percentages for 1987 were 36.3, 42.4, 21.1, and 0.3. In 1987, China, Hong Kong, Mexico, and the Republic of South Africa supplied over 72% of this antimony (U.S. Bureau of Mines 1989a). China is, by far, our largest supplier of antimony, most of which is imported as antimony metal. Importation of antimony has generally increased in recent years. In comparison to the figures for 1987 and 1988 given above, imports ranged from 12,098 to 20,086 metric tons between 1977 and 1981 (Plunkert 1982). States that have companies that imported more than 10,000 pounds of antimony and its compounds in 1987 are indicated in Table 4-1.

The United States exported 624 metric tons of antimony metal, alloys, and scrap and 1,227 metric tons of antimony oxide in 1988 (U.S. Bureau of Mines 1989a). Canada is the largest recipient of these exports. No clear trend in antimony exports was evident in the last decade (Llewellyn 1988; Plunkert 1982).

4.3 USE

Antimony is a brittle metal that is not readily fabricated and has no significant use in its unalloyed state. It is alloyed with lead and other metals to increase their hardness, mechanical strength, corrosion resistance, and electrochemical stability or decrease their coefficient of friction. Some antimony alloys expand slightly upon cooling, a valuable property for use in type metal and other castings. Most primary antimony metal, 55% in 1988, as well as most of secondary antimony, goes into antimonial lead, which is used primarily in grid metal for lead acid storage batteries. In this application, the antimony imparts fluidity and electrical stability, and increases the fatigue strength and creep resistance of the lead (Carapella 1978). Other uses in decreasing order of importance are solder, sheet and pipe, bearing metal, and bearings, castings, and type metal. Antimony is also used in ammunition and cable sheathing. Other uses, including nonantimonial lead alloys (e.g., pewter), accounted for 21.7% of 1988 metal consumption (U.S. Bureau of Mines 1989a). The level of antimony in grid metal ranges from 2.5% to 5% (Carapella 1978). Antimony levels in other antimony alloys range up to 23%. High-purity antimony is used as a dopant in semiconductors. Intermetallic compounds of antimony such as aluminum antimonide (AlSb), gallium antimonide (GaSb), and indium antimonide (InSb) are used for thermoelectric devices such as infrared detectors and diodes (Gudzovskij 1983; Herbst et al. 1985).

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The most common end-use of antimony compounds is antimony trioxide for fire retardation. In 1985, 15,500 metric tons of antimony oxides, amounting to 85% of production, were consumed for this use (Sutker 1988). Antimony trioxide in a suitable organic solvent is used as a fire retardant for plastics, textiles, rubber, adhesives, pigments, and paper (U.S. Bureau of Mines 1989a). According to Bureau of Mine estimates, 56% of the end-use consumption of primary antimony in the United States was for flame retardants, as opposed to 23% in metal products and 21% in nonmetal products (U.S. Bureau of Mines 1989a). Nonmetal products include enamels for plastics, metal, and ceramics, decolorizing and refining agents in special optical glass and other glasses, stabilizers in plastics, pigments in paints and ceramics, vulcanization agents, ammunition primers, and fireworks (U.S. Bureau of Mines 1989a; Herbst et al. 1985; Ludersdorf et al. 1987). The number of companies in each state that used more than 10,000 pounds of antimony and its compounds in 1987 is included in Table 4-1. The most common general use of antimony and its compounds is as a formulation or article component.

Some trivalent organic antimony compounds (e.g., potassium or sodium antimony tartrate) are used to treat bilharziasis (schistosomiasis) (Swellengrebel and Sterman 1961).

4.4 DISPOSAL

Much of the antimony used in antimonial lead, most of which comes from auto batteries, is recycled. This is evident from the large amount of secondary antimony production. Little information concerning the disposal of antimony and its compounds has been found in the literature. Wastes from mining and smelting are generally disposed of in landfills. This is evident from the amounts of releases to land from companies that produce antimony and its compounds (Section 5.2.1). In addition, many companies transfer their antimony wastes to publicly-owned treatment works or to off-site facilities for disposal. Plastics and articles of clothing that contain small amounts of antimony oxide flame retardants will generally be placed in landfills or incinerated along with normal industrial or municipal trash.

Antimony and its compounds have been designated as priority pollutants by EPA (1988). As such, persons who generate, transport, treat, store, or dispose of antimony-containing material must comply with regulations of the federal Resource Conservation and Recovery Act (RCRA). No limitations on the disposal of antimony ore from mines and mills have been promulgated in the Code of Federal Regulations (EPA 1988).