



# 2017 Minerals Yearbook

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## ARSENIC [ADVANCE RELEASE]

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# ARSENIC

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Domestic tables were prepared by Samir Hakim, statistical assistant.

In 2017, the United States produced no arsenic and relied mainly on Morocco and China for arsenic trioxide and China for arsenic metal (table 2). No arsenic trioxide or commercial-grade arsenic metal has been produced domestically since 1985 following the closure of the ASARCO Inc. copper smelter in Tacoma, WA, but shipments from the remaining stockpile continued until 1994. Arsenic trioxide was used mostly for the production of arsenic acid used in the formulation of chromated copper arsenate (CCA), a pesticide and preservative used to treat wood products for nonresidential applications such as guard rails, pilings, posts, railroad ties, and utility poles. Arsenic compounds were also used in fertilizers, fireworks, glassmaking, and pesticides. Arsenic metal was used for electronics applications and in nonferrous alloys. In 2017, estimated world production of arsenic trioxide was 34,600 metric tons (t), 3% less than estimated production in 2016 (table 3). Production data for arsenic metal were not available.

## Consumption

In 2017, domestic apparent consumption of arsenic, based on the estimated arsenic content of imports, was 6,920 t, an increase of 13% from the 6,120 t consumed in 2016 (table 1). The value of arsenic compounds and metal imported in 2017 was approximately \$6.6 million (table 2). Known domestic consumers of arsenic trioxide that produced CCA were Arch Wood Protection, Inc. (Atlanta, GA), a subsidiary of Lonza Group Ltd. (Switzerland); Koppers Inc. (Pittsburgh, PA); and Viance LLC (Charlotte, NC).

Arsenic metal was used to harden ammunition, in solders, and in other applications. Grids and posts in lead-acid storage batteries are strengthened by the addition of arsenic metal. Arsenic is one of several metals used as an antifriction additive in babbitt metals (alloys that are used for bearings). High-purity (99.9999%) arsenic metal was used to produce gallium-arsenide (GaAs), indium-arsenide, and indium-gallium-arsenide semiconductors that were widely used in biomedical, communications, computer, electronics, and photovoltaic applications. Arsenic may be used for germanium-arsenide-selenide or GaAs specialty optical materials. The value of worldwide GaAs device revenues was reportedly \$8.8 billion in 2017, an increase of 7% from that in 2016 (Higham, 2017, 2018). More information on GaAs use can be found in the Gallium chapter of the 2017 U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

## Prices

According to U.S. Census Bureau data, the value of arsenic trioxide originating from Morocco averaged 68 cents per kilogram, unchanged from the previous year. The value

of arsenic metal imported from China averaged \$1.56 per kilogram, a decrease of 17% from that in 2016 (table 1).

## Foreign Trade

In 2017, domestic imports of arsenic compounds were estimated to contain about 5,980 t of arsenic, an increase of 12% compared with the 5,320 t imported in 2016 (table 1). Arsenic trioxide, which accounted for more than 99% of the gross weight of compound imports in 2017, contains about 76% arsenic. In 2017, China was the source of 55% of the arsenic trioxide imported into the United States; Morocco was the source of 44% (table 2).

In 2017, the United States imported 942 t of arsenic metal, a 19% increase compared with the 793 t of arsenic metal imported in 2016. China was the leading source of arsenic metal in 2017, accounting for 88% of United States metal imports (table 2).

According to U.S. Census Bureau data, exports of arsenic metal from the United States in 2017 decreased to 698 t from 1,760 t in 2016. Export destinations included Jamaica (40%), Honduras (25%), China (8%), Guatemala (7%), the Dominican Republic (4%), and Argentina, Belize, and Mexico (3% each). Nine additional countries accounted for the remaining 7% of exports. Because the United States did not produce arsenic metal, it was thought that much of the material reported as exports of metal under the Harmonized Tariff Schedule of the United States code 2804.80.0000 was arsenic-containing compounds and waste, as well as nonferrous alloys containing relatively minor quantities of arsenic. The exports also may have included arsenic-containing electronic waste, such as circuit boards and other electronic components destined for reclamation and recycling. Therefore, actual exports of arsenic metal were likely significantly less than reported.

## World Review

In 2017, commercial-grade arsenic trioxide was thought to have been recovered from the processing of nonferrous ores or concentrates. Reduction of arsenic trioxide to arsenic metal was believed to have accounted for all world output of commercial-grade (99%-pure) arsenic metal. Arsenic-containing residues and smelter dusts recovered from nonferrous metals plants in several countries may not have been processed to recover commercial-grade arsenic trioxide in 2017 and may have been stockpiled for future treatment or disposed. Production data for most countries were estimated.

In 2017, China produced an estimated 24,000 t of arsenic trioxide and remained the world's leading producer, followed by Morocco with 6,000 t. Output from these countries accounted for an estimated 87% of total world production. Arsenic production in China was estimated to be lower than that in

2016 because of increases in environmental regulations which caused some arsenic producers to stop production. In China, based on historical information, arsenic was believed to have been recovered as a byproduct of smelting gold ores containing orpiment ( $\text{As}_2\text{S}_3$ ) and realgar ( $\text{AsS}$ ), the more common ore minerals of arsenic, in addition to reclaiming arsenic as a byproduct of nonferrous smelting (Peters and others, 2002, p. 182).

Prefeasibility and technical studies were under way for the restart of Gorniy, an ex-military plant in Russia, which recycled arsenic from Soviet-era chemical weapons. The plant would produce arsenic acid and high-purity arsenic metal for civilian use from military chemical waste (Sparks, 2017).

## Outlook

Specific industrial applications, such as marine timber, plywood roofing, and utility poles, are expected to continue to use CCA-treated wood. High-purity arsenic metal is used in military, solar cells, space, and telecommunications applications. The use of GaAs components in cellular handsets and increased penetration of GaAs-based light-emitting diodes, automotive lighting, and other applications is expected to increase arsenic metal consumption.

## References Cited

- Higham, Eric, 2017, RF GaAs device revenue hits record level in 2016—Report summary: Strategy Analytics, March 15. (Accessed April 4, 2017, at <https://www.strategyanalytics.com/access-services/components/advanced-semiconductors/reports/report-detail/rf-gaas-device-revenue-hits-record-level-in-2016?slid=129457&spg=3>.)
- Higham, Eric, 2018, RF GaAs device revenue reaches record levels in 2017—Report summary: Strategy Analytics, April 2. (Accessed April 20, 2018, at <https://www.strategyanalytics.com/access-services/components/advanced-semiconductors/reports/report-detail/rf-gaas-device-revenue-reaches-record-levels-in-2017?slid=454456&spg=2#.Wt0u4sPwZyw>.)
- Peters, S.G., Jiazhan, Huang, and Chenggui, Jing, 2002, Geology and geochemistry of sedimentary-rock-hosted Au deposits of the Qinling fold belt (Chuan-Shan-Gan) area, Shaanxi, Sichuan, and Gansu Provinces, P.R. China, chap. 4 of Peters, S.G., ed., Geology, geochemistry, and geophysics of sedimentary rock-hosted Au deposits in P.R. China: U.S. Geological Survey Open-File Report 02–131, p. 168–254.
- Sparks, Polina, 2017, Russian exmilitary plant revives arsenic plans: Argus Media Group Metal-Pages, February 20. (Accessed March 20, 2018, via <http://www.argusmedia.com/metals/>.)

## GENERAL SOURCES OF INFORMATION

### U.S. Geological Survey Publications

- Arsenic. Ch. in Mineral Commodity Summaries, annual.
- Arsenic. Ch. in United States Mineral Resources, Professional Paper 820, 1973.
- Arsenic (As). Ch. in Metal Prices in the United States Through 2010, Scientific Investigations Report 2012–5188, 2013.
- Arsenic in Minnesota Groundwater, 2014 (<https://www2.usgs.gov/envirohealth/geohealth/articles/2014-10-03-arsenic.html>).
- Gallium. Ch. in Minerals Yearbook, annual.
- Historical Statistics for Mineral and Material Commodities in the United States. Data Series 140.
- Public Perception Impedes Prevention of Arsenic Exposure, 2015 ([https://www2.usgs.gov/envirohealth/geohealth/articles/2015-08-11-understanding\\_arsenic.html](https://www2.usgs.gov/envirohealth/geohealth/articles/2015-08-11-understanding_arsenic.html)).
- The Effectiveness of Water-Treatment Systems for Arsenic Used in 11 Homes in Southwestern and Central Ohio, 2013. Scientific Investigations Report 2015–5156, 2016.

### Other

- American Wood Protection Association.
- Arsenic. Ch. in Mineral Facts and Problems, U.S. Bureau of Mines Bulletin 675, 1985.
- Arsenic (8th ed.). Roskill Information Services Ltd., 1992.
- Arsenic and Old Waste, A Report of the U.S. Interagency Working Group on Industrial Ecology, Material and Energy Flows. U.S. Environmental Protection Agency, 1998.
- Gallium and Gallium Arsenide—Supply, Technology, and Uses. U.S. Bureau of Mines Information Circular 9208, 1988.
- Materials Flow of Arsenic in the United States. U.S. Bureau of Mines Information Circular 9382, 1994.

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

(Metric tons of contained arsenic unless otherwise specified)

|   | 2013  | 2014  | 2015  | 2016               | 2017  |
|---|-------|-------|-------|--------------------|-------|
| Imports:  |       |       |       |                    |       |
| Metal <sup>2</sup>                                  | 514   | 688   | 514   | 793                | 942   |
| Compounds <sup>3</sup>                              | 6,290 | 5,260 | 5,920 | 5,320 <sup>†</sup> | 5,980 |
| Total   | 6,810 | 5,940 | 6,430 | 6,120              | 6,920 |
| Exports, metal <sup>2</sup>                         | 1,630 | 2,970 | 1,670 | 1,760              | 698   |
| Apparent consumption <sup>4</sup>                   | 6,810 | 5,940 | 6,430 | 6,120              | 6,920 |
| Price, average: <sup>5</sup>                        |       |       |       |                    |       |
| Metal, China                   dollars per kilogram | 1.59  | 1.64  | 1.85  | 1.89               | 1.56  |
| Trioxide, Morocco           do.                     | 0.60  | 0.66  | 0.64  | 0.68               | 0.68  |

<sup>†</sup>Revised. do. Ditto.

<sup>1</sup>Table includes data available through May 14, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Listed as metal only, but may include alloys, waste, and compounds.

<sup>3</sup>Includes arsenic acid, arsenic sulfides, and arsenic trioxide. Arsenic content estimated from the reported gross weight of imports; arsenic trioxide contains nearly 76% arsenic by weight and accounts for more than 99% of imports.

<sup>4</sup>Estimated to be the same as imports.

<sup>5</sup>Landed duty-paid unit value based on U.S. imports for consumption.

TABLE 2  
U.S. IMPORTS FOR CONSUMPTION OF ARSENIC PRODUCTS<sup>1</sup>

| Class and country or locality | 2016                          |                      | 2017                          |                      |
|-------------------------------|-------------------------------|----------------------|-------------------------------|----------------------|
|                               | Gross weight<br>(metric tons) | Value<br>(thousands) | Gross weight<br>(metric tons) | Value<br>(thousands) |
| Arsenic trioxide:             |                               |                      |                               |                      |
| Belgium                       | 2                             | \$8                  | 84                            | \$36                 |
| China                         | 3,540                         | 1,640                | 4,350                         | 1,940                |
| Germany                       | (2)                           | 19                   | --                            | --                   |
| Morocco                       | 3,470                         | 2,340                | 3,470                         | 2,350                |
| Total                         | 7,000                         | 4,000                | 7,900                         | 4,320                |
| Arsenic sulfides, Italy       | 35                            | 98                   | --                            | --                   |
| Arsenic acid, China           | --                            | --                   | (2)                           | 4                    |
| Arsenic metal:                |                               |                      |                               |                      |
| China                         | 728                           | 1,380                | 827                           | 1,290                |
| France                        | (2)                           | 3                    | --                            | --                   |
| Germany                       | 6                             | 543                  | 2                             | 490                  |
| Hong Kong                     | 20                            | 30                   | 76                            | 104                  |
| Japan                         | 39                            | 300                  | 37                            | 347                  |
| United Kingdom                | (2)                           | 11                   | (2)                           | 6                    |
| Total                         | 793                           | 2,260                | 942                           | 2,240                |

-- Zero.

<sup>1</sup>Table includes data available through May 14, 2018. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>Less than ½ unit.

Source: U.S. Census Bureau.

TABLE 3  
ARSENIC TRIOXIDE: WORLD PRODUCTION, BY COUNTRY OR LOCALITY<sup>1,2</sup>

(Metric tons)

| Country or locality <sup>3</sup> | 2013             | 2014                | 2015                | 2016                | 2017               |
|----------------------------------|------------------|---------------------|---------------------|---------------------|--------------------|
| Belgium <sup>e</sup>             | 1,000            | 1,000               | 1,000               | 1,000               | 1,000              |
| Bolivia                          | 120              | 52                  | 33 <sup>r</sup>     | 38 <sup>r</sup>     | 40 <sup>e</sup>    |
| China <sup>e</sup>               | 25,000           | 25,000              | 25,000              | 25,000              | 24,000             |
| Iran <sup>e</sup>                | 110 <sup>r</sup> | 110 <sup>r</sup>    | 110 <sup>r</sup>    | 110 <sup>r</sup>    | 110                |
| Japan <sup>e</sup>               | 45               | 45                  | 45                  | 45                  | 45                 |
| Morocco                          | 8,968            | 3,863 <sup>r</sup>  | 7,566               | 6,122 <sup>r</sup>  | 6,000 <sup>e</sup> |
| Namibia <sup>e</sup>             | 1,520            | 1,520 <sup>r</sup>  | 1,960               | 1,900               | 1,900              |
| Russia <sup>e</sup>              | 1,500            | 1,500               | 1,500               | 1,500               | 1,500              |
| Total                            | 38,300           | 33,100 <sup>r</sup> | 37,200 <sup>r</sup> | 35,700 <sup>r</sup> | 34,600             |

<sup>e</sup>Estimated. <sup>r</sup>Revised.

<sup>1</sup>Table includes data available through May 14, 2018. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to total shown.

<sup>2</sup>Includes calculated arsenic trioxide equivalent of output of elemental arsenic compounds other than arsenic trioxide; inclusion of such materials would not duplicate reported arsenic trioxide production.

<sup>3</sup>In addition to the countries and (or) localities listed, other countries and (or) localities may have produced arsenic, but available information was inadequate to make reliable estimates of output.