



# 2018 Minerals Yearbook

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## ARSENIC [ADVANCE RELEASE]

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# ARSENIC

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In 2018, the United States produced no arsenic and relied mainly on China and Morocco 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-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 2018 and may have been stockpiled for future treatment or disposed. Arsenic trioxide was primarily used to produce the 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 in nonferrous alloys. High-purity arsenic metal was used for semiconductors in a wide variety of applications for the defense, energy, electronics, and telecommunications sectors. In 2018, estimated world production of arsenic trioxide was 33,400 metric tons (t), 3% less than estimated production in 2017 (table 3). Production data for arsenic metal were not available.

## Legislation and Government Programs

Executive Order 13817, “A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals,” was issued on December 20, 2017. Pursuant to the Executive order, the Secretary of the Interior, in coordination with the Secretary of Defense and in consultation with the heads of other relevant executive departments and agencies, was tasked with developing and submitting to the Federal Register a list of minerals defined as critical minerals. On May 18, arsenic was 1 of the 35 minerals or mineral material groups identified as critical (Trump, 2017; U.S. Department of the Interior, 2018).

## Consumption

In 2018, domestic apparent consumption of arsenic, based on the estimated arsenic content of imports, was 6,470 t, a decrease of 7% from the 6,920 t consumed in 2017 (table 1). The value of arsenic compounds and metal imported in 2018 was \$6.83 million (table 2). Known domestic consumers of arsenic trioxide that produced CCA were Arch Wood Protection, Inc. (Atlanta, GA), a subsidiary of Lonza Group A.G. (Switzerland); Koppers Inc. (Pittsburgh, PA); and Viance, LLC (Charlotte, NC).

Arsenic metal was used to harden ammunition, in solders, and in other applications. The addition of arsenic metal strengthens grids and posts in lead-acid storage batteries. Arsenic is one of several metals used as an antifriction additive in babbitt metals (alloys 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, light-emitting diodes (LEDs), and photovoltaic applications. Arsenic is also used for germanium-arsenide-selenide or GaAs specialty optical materials. GaAs devices generate less signal noise than other semiconductor materials; as a result, GaAs semiconductors are useful in weak-signal amplification applications such as wireless communications. The value of worldwide GaAs device revenues was reportedly \$8.9 billion in 2018, a slight increase from that in 2017. About one-half of the GaAs wafers produced were from China. The top five producers of GaAs wafers, in descending order, were Freiburger Compound Materials GmbH (Freiberg, Germany); AXT, Inc. (Fremont, CA); Sumitomo Electric Industries, Ltd. (Osaka, Japan); China Crystal Technologies Co., Ltd. (Beijing, China); and Shenzhou Crystal Technologies Development Co., Ltd. (Xinxiang, China) (Higham, 2018, 2019). More information on GaAs use can be found in the gallium chapter of the 2018 U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

## Prices

According to U.S. Census Bureau unrounded data, the value of arsenic trioxide originating from Morocco averaged 75 cents per kilogram, a 10% increase from the previous year. The value of arsenic metal imported from China averaged \$1.43 per kilogram, a decrease of 8% from that in 2017 (table 1).

## Foreign Trade

In 2018, domestic imports of arsenic compounds were estimated to contain about 5,540 t of arsenic, a decrease of 7% compared with the 5,980 t imported in 2017 (table 1). Arsenic trioxide, which accounted for all of the gross weight of compound imports in 2018, contains about 76% arsenic. In 2018, China was the source of 52% of the arsenic trioxide imported into the United States; Morocco was the source of 40% (table 2).

In 2018, the United States imported 929 t of arsenic metal, a slight decrease compared with the 942 t of arsenic metal imported in 2017. China was the leading source of arsenic metal in 2018, accounting for 96% of United States metal imports (table 2).

According to U.S. Census Bureau data, exports of arsenic metal from the United States in 2018 decreased to 107 t from 698 t in 2017. Export destinations included China (66%), India (11%), Mexico (9%), the Dominican Republic (5%), and Japan (4%). 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, it is likely that actual exports of arsenic metal were significantly less than reported.

## World Review

In 2018, commercial-grade arsenic trioxide was thought to have been recovered from the processing of nonferrous ores or concentrates, such as copper, gold, and lead. 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 2018 and may have been stockpiled for future treatment or disposal. Production data for most countries were estimated.

In 2018, 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 90% of total estimated world 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).

## 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, space, and telecommunications applications, and in solar cells. The use of GaAs components in cellular handsets and increased penetration of GaAs-based LEDs, automotive lighting, and other applications are expected to increase arsenic metal consumption.

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

(Metric tons of contained arsenic unless otherwise specified)

	2014	2015	2016	2017	2018
Imports:					
Metal <sup>2</sup>	688	514	793	942	929
Compounds <sup>3</sup>	5,260	5,920	5,320 <sup>r</sup>	5,980	5,540
Total	5,940	6,430	6,120 <sup>r</sup>	6,920	6,470
Exports, metal <sup>2</sup>	2,970	1,670	1,760	698	107
Apparent consumption <sup>4</sup>	5,940	6,430	6,120 <sup>r</sup>	6,920	6,470
Price, average: <sup>5</sup>					
Metal, China                   dollars per kilogram	1.64	1.85	1.89	1.56	1.43
Trioxide, Morocco           do.	0.66	0.64	0.68	0.68	0.75

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

<sup>1</sup>Table includes data available through August 27, 2019. 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 nearly all 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>1,2</sup>

Class and country or locality	2017		2018	
	Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
Arsenic trioxide:				
Belgium	84	\$36	350	\$167
China	4,350	1,940	3,830	1,710
Germany	--	--	4	34
Morocco	3,470	2,350	2,900	2,170
New Zealand	--	--	108	87
United Arab Emirates	--	--	120	96
Total	7,900	4,320	7,320	4,260
Arsenic acid, China	(3)	4	--	--
Arsenic metal:				
China	827	1,290	890	1,270
Germany	2	490	4	830
Hong Kong	76	104	--	--
Japan	37	347	29	436
United Kingdom	(3)	6	6	32
Total	942	2,240	929	2,570

-- Zero.

<sup>1</sup>Table includes data available through August 27, 2019. Data are rounded to no more than three significant digits; may not add to totals shown.

<sup>2</sup>There were no imports of arsenic sulfides in 2017 or 2018.

<sup>3</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, gross weight)

Country or locality <sup>3</sup>	2014	2015	2016	2017	2018
Belgium <sup>e</sup>	1,000	1,000	1,000	1,000	1,000
Bolivia	52	33	38	40 <sup>e</sup>	40 <sup>e</sup>
China	25,000 <sup>e</sup>	25,000 <sup>e</sup>	25,000	24,000	24,000 <sup>e</sup>
Iran <sup>e</sup>	110	110	110	110	110
Japan <sup>e</sup>	45	45	45	45	45
Morocco	3,863	7,566	7,600 <sup>r</sup>	6,879 <sup>r</sup>	6,000 <sup>e</sup>
Namibia	1,520	1,960	1,900 <sup>e</sup>	700 <sup>r,e</sup>	700 <sup>e</sup>
Russia <sup>e</sup>	1,500	1,500	1,500	1,500	1,500
Total	33,100	37,200	37,200 <sup>r</sup>	34,300 <sup>r</sup>	33,400

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

<sup>1</sup>Table includes data available through April 9, 2019. All data are reported unless otherwise noted. Totals and estimated data are rounded to no more than three significant digits; may not add to totals 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 or localities may have produced arsenic, but available information was inadequate to make reliable estimates of output.