



# 2020 Minerals Yearbook

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## ARSENIC [ADVANCE RELEASE]

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# ARSENIC

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**Domestic tables were prepared by Benjamin N. Bryden, statistical assistant.**

In 2020, the United States produced no arsenic and relied mainly on China and Morocco for arsenic trioxide ( $As_2O_3$ ) and China (including Hong Kong) for arsenic metal (table 2). No  $As_2O_3$  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  $As_2O_3$  in 2020 and may have been stockpiled for future treatment or disposed.  $As_2O_3$  was used primarily 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, roller coasters, shakes and shingles, and utility poles. Arsenic compounds also were used in fertilizers, fireworks, glassmaking, medicine, 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, electronics, energy, and telecommunications sectors. In 2020, estimated world production of  $As_2O_3$  was 60,000 metric tons (t), 11% less than the revised production in 2019 (table 3). Production data for arsenic metal were not available.

## Government Actions and Legislation

Executive Order (EO) 13817, “A Federal Strategy To Ensure Secure and Reliable Supplies of Critical Minerals,” was issued on December 20, 2017. Pursuant to the EO, 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, 2018, arsenic was 1 of the 35 minerals or mineral material groups identified as critical. On June 4, 2019, the Trump administration released “A Federal Strategy To Ensure a Reliable Supply of Critical Minerals.” The strategy directed the U.S. Department of the Interior to assist in locating domestic sources of critical minerals and provide information for the study and production of the minerals (Trump, 2017; U.S. Department of the Interior, 2018, 2019).

The U.S. Geological Survey (USGS) was tasked to periodically reevaluate and revise as necessary the process for compiling the list of critical minerals. In a report published in February 2020, the USGS described a methodology using three factors to determine the supply risk for nonfuel minerals, which were the likelihood of a foreign supply disruption, the dependency of U.S. manufacturers on foreign supplies, and the ability of U.S. manufacturers to withstand a supply disruption (Nassar and others, 2020).

## Consumption

In 2020, domestic apparent consumption of arsenic, based on the estimated arsenic content of imports, equaled 8,300 t, an increase of 11% from the 7,480 t consumed in 2019 (table 1). The value of arsenic compounds and metal imported in 2020 was \$7.93 million, a 10% increase from that in 2019 (table 2). Much of the consumption of  $As_2O_3$  was in the production of CCA. Known domestic consumers of CCA were Arch Wood Protection, Inc. (Atlanta, GA), a subsidiary of Lonza Group A.G. (Switzerland); A Meredith Schneider Co. (East Point, GA); Brown Wood Preserving Co., Inc. (Louisville, KY); Koppers Inc. (Pittsburgh, PA); Stella-Jones Corp. (Pittsburgh, PA); Thomasson Co. (Philadelphia, MS); and Viance, LLC (Charlotte, NC).  $As_2O_3$  also was used in the treatment of acute promyelocytic leukemia (National Cancer Institute, 2019).

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 was 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, infrared light-emitting diodes (LED), integrated circuit, microwave frequency integrated circuits, monolithic microwave integrated circuits, optical windows, other LEDs, and photovoltaic cells. 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. Despite the global coronavirus disease 2019 (COVID-19) pandemic closures, shipping constraints, and the shortage of semiconductor production, total revenues from GaAs devices increased in 2020 because of increases in implementation of fifth generation (5G) technology standards for broadband cellular networks and consumer devices. A variety of GaAs wafer manufacturers, ranging from large multinational corporations to small privately owned companies, competed in this industry globally, but the top six producing companies—AXT Inc.; China Crystal Technologies Co. Ltd.; DOWA Electronics Materials Co., Ltd.; Freiberger Compound Materials GmbH; Sumitomo Electric Industries, Ltd.; and Wafer Technology Ltd.—accounted for more than 75% of the market. China and Japan each accounted for about 30% of the production of GaAs, followed by Europe (20%), North America (15%), and rest of the world (5%) (Maia Research Co., Ltd., 2019, p. 1, 17; Higham, 2021a, c). More information on GaAs use can be found in the Gallium chapter of the 2020 U.S. Geological Survey Minerals Yearbook, volume I, Metals and Minerals.

## Prices

According to U.S. Census Bureau unrounded data, the unit value of  $\text{As}_2\text{O}_3$  originating from Morocco averaged 83 cents per kilogram in 2020, a 6% increase from that in 2019, and  $\text{As}_2\text{O}_3$  from China averaged 43 cents per kilogram, a 7% decrease. The unit value of arsenic metal imported from China averaged \$1.51 per kilogram, a decrease of 21% from that in 2019 (table 1).

## Foreign Trade

In 2020, domestic imports of arsenic compounds were estimated to contain 7,780 t of arsenic, an increase of 10% compared with the 7,090 t imported in 2019 (table 1).  $\text{As}_2\text{O}_3$ , which contains about 76% arsenic, accounted for 97% of the arsenic content of compound imports in 2020. In 2020, China was the source of 58% of the  $\text{As}_2\text{O}_3$  imported into the United States; Morocco was the source of 35% (table 2).

In 2020, the United States imported 522 t of arsenic metal, a 34% decrease compared with the 391 t of arsenic metal imported in 2019. The leading source of arsenic metal in 2020 was China, including Hong Kong, and accounted for 97% of United States metal imports (table 2).

According to U.S. Census Bureau data, exports of arsenic metal (under the Schedule B number 2804.80.0000) from the United States in 2020 decreased by 48% to 29 t from 56 t in 2019. This was the sixth consecutive year of decreases. Export destinations included Peru (31%), Ecuador (22%), Japan (15%), France (13%), and Germany (11%). Because the United States did not produce arsenic metal and the other Schedule B number for arsenic was not used, it was thought that much of the material reported as exports of metal was arsenic-containing compounds and waste and nonferrous alloys containing relatively minor quantities of arsenic. Therefore, it is likely that actual exports of arsenic metal were significantly less than reported.

## World Review

In 2020, commercial-grade  $\text{As}_2\text{O}_3$  was thought to have been recovered from the processing of nonferrous ores or concentrates, such as copper, gold, and lead. Reduction of  $\text{As}_2\text{O}_3$  to arsenic metal was thought 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  $\text{As}_2\text{O}_3$  in 2020 and may have been stockpiled for future treatment or disposal and could be large source of future supply. Production data for most countries were estimated.

In 2020, Peru produced an estimated 27,000 t of  $\text{As}_2\text{O}_3$  and was the world's leading producer, followed by China with 24,000 t and Morocco with 7,690 t. Output from these countries accounted for an estimated 98% of total world production. In China, based on historical information, arsenic was believed to have been recovered as a byproduct of smelting gold ores containing orpiment ( $\text{As}_2\text{O}_3$ ) 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).

In Morocco, production was from Managem S.A.'s Bou-Azzer cobalt mine. In 2020, the mine produced 7,690 t of arsenic, a 52% increase from production in 2019. In the first quarter of 2020, the company completed the installation of a new gravimetric concentration unit at the Bou-Azzer cobalt mine (Managem S.A., 2021, p. 30, 104).

## 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 expected to be used increasingly in military, space, and telecommunications applications and in solar cells. Despite the COVID-19 pandemic that constrained global economies, increased geopolitical tensions, and a global semiconductor shortage, the use of GaAs components increased in 2020 and is expected to increase in 2021. The increase will be mostly in the 5G devices and networks (Higham, 2021b).

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

(Metric tons, arsenic content)

	2016	2017	2018	2019	2020
Imports:					
Metal <sup>2</sup>	793	942	929	391	522
Compounds <sup>3</sup>	5,320	5,980	5,540	7,090	7,780
Total	6,120	6,920	6,470	7,480	8,300
Exports, metal <sup>2</sup>	1,760	698	107	56	29
Apparent consumption <sup>4</sup>	6,120	6,920	6,470	7,480	8,300
Price, average: <sup>5</sup>					
Metal, China      dollars per kilogram	1.89	1.56	1.43	1.93 <sup>r</sup>	1.51
Trioxide, China    do.	0.46	0.45	0.44	0.46	0.43
Trioxide, Morocco    do.	0.68	0.68	0.75	0.78	0.83

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

<sup>1</sup>Table includes data available through March 5, 2021. 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, compounds, and waste.

<sup>3</sup>Includes arsenic acid, arsenic sulfides, and arsenic trioxide. Arsenic content calculated 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. Source: U.S. Census Bureau.

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

Class and country or locality	2019		2020	
	Gross weight (metric tons)	Value (thousands)	Gross weight (metric tons)	Value (thousands)
<b>Arsenic trioxide:</b>				
Belgium	336	\$139	544	\$121
China	5,600	2,570	5,820	2,490
Germany	19	68	47	179
Morocco	3,180	2,490	3,460	2,860
Russia	--	--	144	100
<b>Total</b>	<b>9,130</b>	<b>5,270</b>	<b>10,000</b>	<b>5,750</b>
<b>Arsenic sulfide, Germany</b>	<b>--</b>	<b>--</b>	<b>2</b>	<b>15</b>
<b>Arsenic acid:</b>				
China	41	46	--	--
Malaysia	186	247	252	269
<b>Total</b>	<b>228</b>	<b>293</b>	<b>252</b>	<b>269</b>
<b>Arsenic metal:</b>				
China	338	653 <sup>r</sup>	466	706
Germany	3	611	4	814
Hong Kong	--	--	40	44
Japan	41	367	11	326
Taiwan	8	24	--	--
United Kingdom	(2)	2	--	--
<b>Total</b>	<b>391</b>	<b>1,660<sup>r</sup></b>	<b>522</b>	<b>1,890</b>

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

<sup>1</sup>Table includes data available through March 5, 2021. 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, gross weight)

Country or locality <sup>3</sup>	2016	2017	2018	2019	2020
Belgium <sup>e</sup>	1,000	1,000	1,000	1,000	1,000
Bolivia	38	20	238	120	100 <sup>e</sup>
China <sup>e</sup>	25,000	24,000	24,000	24,000	24,000
Iran	-- <sup>r</sup>	400 <sup>r</sup>	-- <sup>r</sup>	-- <sup>r</sup>	-- <sup>e</sup>
Japan <sup>e</sup>	45	45	45	40 <sup>r</sup>	40
Morocco	7,600	6,879	5,578	5,055 <sup>r</sup>	7,690
Namibia	1,900 <sup>e</sup>	700 <sup>e</sup>	--	--	--
Peru	33,000	32,000	29,000	35,000	27,000
Russia	1,500 <sup>e</sup>	1,500 <sup>e</sup>	-- <sup>r</sup>	2,226 <sup>r</sup>	120 <sup>e</sup>
<b>Total</b>	<b>70,100<sup>r</sup></b>	<b>66,500<sup>r</sup></b>	<b>59,900<sup>r</sup></b>	<b>67,400<sup>r</sup></b>	<b>60,000</b>

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

<sup>1</sup>Table includes data available through April 20, 2021. All data are reported unless otherwise noted; totals may include estimated data. 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.