U.S. Department of the Interior
U.S. Geological Survey

MINERAL COMMODITY SUMMARIES 2025

Abrasives
Aluminum
Antimony
Arsenic
Asbestos
Barite
Bauxite
Beryllium
Bismuth
Boron
Bromine
Cadmium
Cement
Cesium
Chromium
Clays
Cobalt
Copper
Diamond
Diatomite
Feldspar
Fluorspar
Gallium
Garnet
Gemstones
Germanium
Gold
Graphite
Gypsum
Hafnium
Helium
Indium
Iodine
Iron and Steel
Iron Ore
Iron Oxide Pigments
Kyanite
Lead
Lime
Lithium
Magnesium
Manganese
Mercury
Mica
Molybdenum
Nickel
Niobium
Nitrogen
Palladium
Peat
Perlite
Phosphate Rock
Platinum
Potash
Pumice
Quartz
Rare Earths
Rhenium
Rubidium
Salt
Sand and Gravel
Scandium
Selenium
Silicon
Silver
Soda Ash
Stone
Strontium
Sulfur
Talc
Tantalum
Tellurium
Thallium
Thorium
Tin
Titanium
Tungsten
Vanadium
Vermiculite
Wollastonite
Yttrium
Zeolites
Zinc
Zirconium

Version 1.2, March 2025

USGS
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Cover: Photograph of 1 of the 66 antennas that make up the Atacama Large Millimeter/submillimeter Array (ALMA) pointed at the moon. ALMA, which is operated by the European Southern Observatory (ESO), was constructed in 2013 and is located at an elevation of 5,000 meters on the Chajnantor Plateau in the Andes Mountains in Chile because of the location's low humidity and atmospheric interference. ALMA's dishes are not mirrors but have surfaces of metallic panels. The panels were constructed from materials such as aluminum (p. 32), carbon fiber reinforced polymer, and steel (p. 94). In addition, the receivers and motion-control devices contain many other mineral commodities. The long wavelengths that ALMA's antennas detect mean that the surfaces are accurate to within 25 micrometers—much less than the thickness of a sheet of paper. Not only are the dish surfaces carefully controlled, but the antennas can be steered precisely and pointed to an angular accuracy of 0.6 arcseconds (1 arcsecond is 1/3600 of a degree). This is accurate enough to detect a golf ball at a distance of 15 kilometers. Photograph by S. Otarola, ESO.

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Germanium
Gold
Graphite
Gypsum
Hafnium
Helium
Indium
Iodine
Iron and Steel
Iron Ore
Iron Oxide Pigments
Kyanite
Lead
Lime
Lithium
Magnesium
Manganese
Mercury
Mica
Molybdenum
Nickel
Niobium
Nitrogen
Palladium
Peat
Perlite
Phosphate Rock
Platinum
Potash
Pumice
Quartz
Rare Earths
Rhenium
Rubidium
Salt
Sand and Gravel
Scandium
Selenium
Silicon
Silver
Soda Ash
Stone
Strontium
Sulfur
Talc
Tantalum
Tellurium
Thallium
Thorium
Tin
Titanium
Tungsten
Vanadium
Vermiculite
Wollastonite
Yttrium
Zeolites
Zinc
Zirconium

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CONTENTS

General:

Mineral Commodities:

INSTANT INFORMATION

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KEY PUBLICATIONS

Minerals Yearbook—These annual publications review the mineral industries of the United States and of more than 180 other countries and localities. They contain statistical data on minerals and materials and include information on economic and technical trends and developments and are available at https://www.usgs.gov/centers/national-minerals-information-center/publications. The three volumes that make up the Minerals Yearbook are volume I, Metals and Minerals; volume II, Area Reports—Domestic; and volume III, Area Reports—International.

Mineral Commodity Summaries—Published on an annual basis, this report is the earliest Government publication to furnish estimates covering nonfuel mineral industry data and is available at https://www.usgs.gov/centers/national-minerals-information-center/mineral-commodity-summaries. Data sheets contain information on the domestic industry structure, Government programs, tariffs, world production and reserves, and 5-year salient statistics for more than 90 individual minerals and materials.

Mineral Industry Surveys—These periodic statistical and economic reports are designed to provide timely statistical data on production, shipments, stocks, and consumption of significant mineral commodities and are available at https://www.usgs.gov/centers/national-minerals-information-center/mineral-industry-surveys. The surveys are issued monthly, quarterly, or at other regular intervals.

Materials Flow Studies—These publications describe the flow of minerals and materials from extraction to ultimate disposition to help better understand the economy, manage the use of natural resources, and protect the environment and are available at https://www.usgs.gov/centers/national-minerals-information-center/materials-flow.

Recycling Reports—These studies illustrate the recycling of metal commodities and identify recycling trends and are available at https://www.usgs.gov/centers/national-minerals-information-center/recycling-statistics-and-information.

Historical Statistics for Mineral and Material Commodities in the United States (Data Series 140)—This report provides a compilation of statistics on production, trade, and use of approximately 90 mineral commodities since as far back as 1900 and is available at https://www.usgs.gov/centers/national-minerals-information-center/historical-statistics-mineral-and-material-commodities.

WHERE TO OBTAIN PUBLICATIONS

- *Mineral Commodity Summaries* and the *Minerals Yearbook* are sold by the U.S. Government Publishing Office. Orders are accepted over the internet at https://bookstore.gpo.gov, by email at ContactCenter@gpo.gov, by telephone toll free (866) 512–1800; Washington, DC, area (202) 512–1800, by fax (202) 512–2104, or through the mail (P.O. Box 979050, St. Louis, MO 63197–9000).

- All current and many past publications are available as downloadable Portable Document Format (PDF) files through https://www.usgs.gov/centers/national-minerals-information-center.

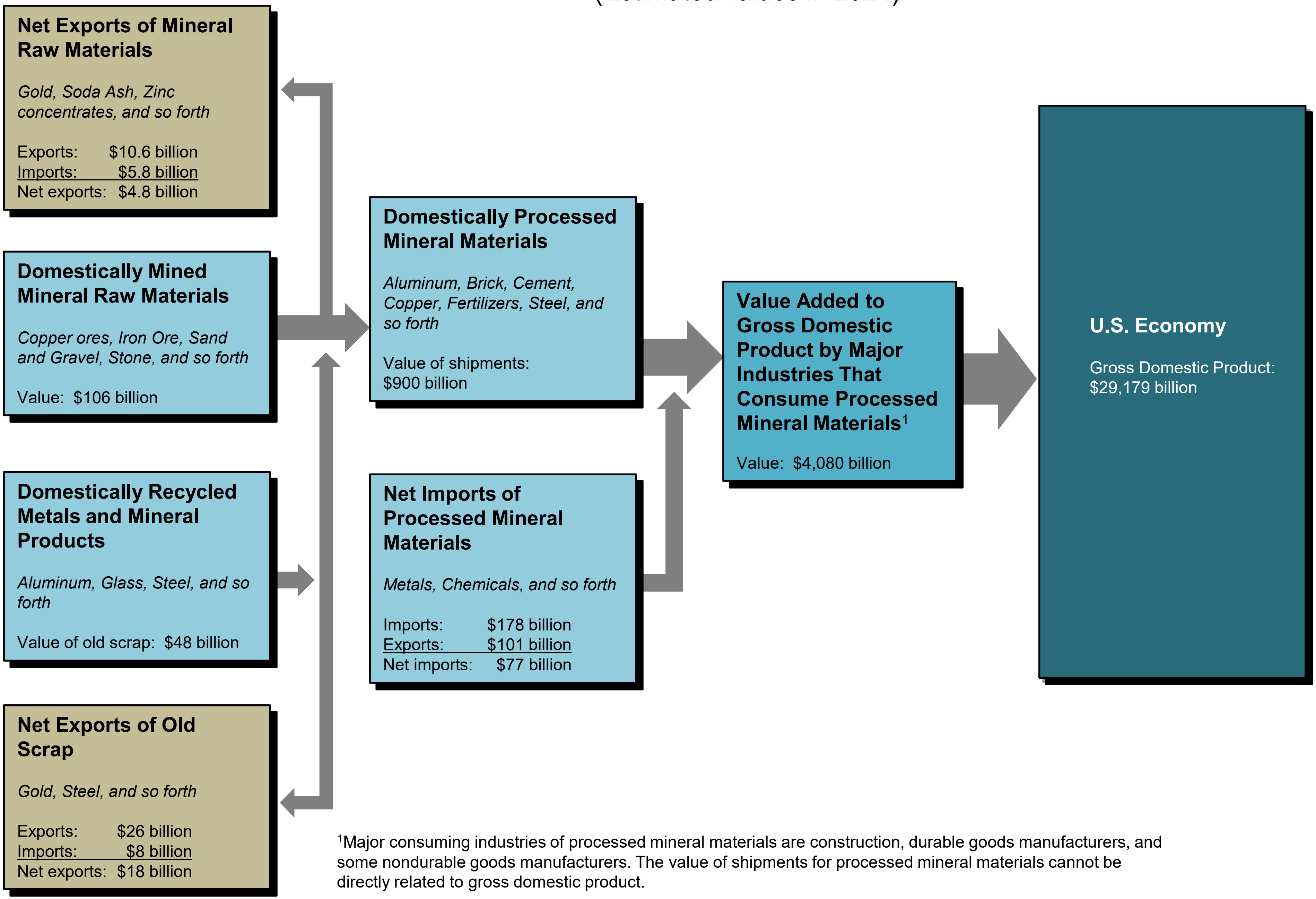
INTRODUCTION

Each mineral commodity chapter of the 2025 edition of the U.S. Geological Survey (USGS) Mineral Commodity Summaries (MCS) includes information on events, trends, and issues for each mineral commodity as well as discussions and tabular presentations on domestic industry structure, Government programs, tariffs, 5-year salient statistics, and world production, reserves, and resources. The MCS is the earliest comprehensive source of 2024 mineral production data for the world. More than 90 individual minerals and materials are covered by two-page synopses.

Abbreviations and units of measure and definitions of selected terms used in the report are in Appendix A and Appendix B, respectively. Reserves and resources information is in Appendix C, which includes “Part A—Resource and Reserve Classification for Minerals” and “Part B—Sources of Reserves Data.” A directory of USGS minerals information country specialists and their responsibilities is in Appendix D.

The USGS continually strives to improve the value of its publications to users. Constructive comments and suggestions by readers of the MCS 2025 are welcomed.

Figure 1.—The Role of Nonfuel Mineral Commodities in the U.S. Economy
(Estimated values in 2024)



[1]Major consuming industries of processed mineral materials are construction, durable goods manufacturers, and some nondurable goods manufacturers. The value of shipments for processed mineral materials cannot be directly related to gross domestic product.

Sources: U.S. Geological Survey and U.S. Department of Commerce.

SIGNIFICANT EVENTS, TRENDS, AND ISSUES

In 2024, the estimated total value of nonfuel mineral production in the United States was $106 billion compared with $105 billion in 2023. The estimated value of metal production in 2024 increased slightly to $33.5 billion from a revised total of $33 billion in 2023. The total estimated value of industrial minerals production was $72.1 billion, unchanged from a revised total of $72.1 billion in 2023 (table 1). Of the total value of industrial minerals production, an estimated $38 billion was construction aggregates production (construction sand and gravel and crushed stone), a 3% increase from that in 2023, and other industrial minerals production value was an estimated $34.2 billion, a 3% decrease from that in 2023. Crushed stone was the leading nonfuel mineral commodity in 2024, with an estimated production value of $25.7 billion, and accounted for 24% of the total estimated value of U.S. nonfuel mineral production.

In 2024, the metal sector had another year of decreasing prices attributed to oversupply in the global market. There were notable reductions in prices of metals from dominant producing countries. In the United States, the value of production of many of the metals used to make lithium-ion batteries, such as cobalt, lithium, and nickel, had 40% to 60% decreases compared with production values in 2023. In the United States, the largest decreases in metal production quantities, in descending order, were nickel, cobalt, platinum, palladium, and cadmium. The reduction in prices caused some domestic mining projects to delay operations or stop processing material.

Gold and silver, however, had some of the highest prices on record in 2024: the estimated production value of gold increased by 9% despite the estimated quantity of gold produced decreasing by 8% compared with that in 2023. The estimated production value of silver increased by 24%, and the quantity of silver produced increased by 6% compared with that in 2023.

For the industrial minerals sector, despite a slight decrease in demand for aggregates, increased prices led to higher production values for aggregates. The largest percentage increases in production value for other industrial minerals, in descending order, were for garnet, gypsum, soda ash, feldspar, perlite, clay (bentonite), and high-purity quartz.

In 2024, one secondary copper smelter became operational in Georgia. One plant in Ohio that processed cobalt and nickel scrap started commercial production of nickel-cobalt intermediate products in 2024. Thirteen commercial recycling plants were either under construction or undergoing expansion in 2024.

The U.S. Geological Survey (USGS) published the “2022 Final List of Critical Minerals” in the Federal Register (87 FR 10381). The 2022 list of critical minerals included 50 mineral commodities. In 2024, there were many initiatives and projects in response to legislation passed previously to advance securing American supply chains and supporting domestic production projects. See the “U.S. Critical Minerals Update” section beginning on page 18 for more details.

Foreign Trade

In 2024, the additional tariffs placed on imports from China remained in place under section 301(b) of the Trade Act of 1974 (19 U.S.C. 2411, as amended): China’s acts, policies, and practices related to technology transfer, intellectual property, and innovation. In September, tariff rates were increased substantially on multiple items including: electric vehicles (EVs) (from 25% to 100%); solar cells whether or not assembled (25% to 50%); semiconductors (25% to 50%, effective January 1, 2025); EV lithium-ion batteries (from 7.5% to 25%); and aluminum and steel products (7.5% to 25%).

On December 2, the U.S. Department of Commerce’s Bureau of Industry and Security announced a package of rules designed to further impair China’s capability to produce advanced-node semiconductors that can be used in the next generation of advanced weapon systems and in artificial intelligence and advanced computing, which have significant military applications. The rules include new export controls on 24 types of semiconductor manufacturing equipment and 3 types of software tools for developing or producing semiconductors as well as Entity List additions and new red flag guidance to address compliance and diversion concerns.

On December 3, China implemented export bans on antimony, gallium, and germanium, expanding existing export restrictions put in place in December 2023 on certain strategic materials and technologies in the “Catalogue of Technologies Prohibited and Restricted from Export in China.” These export restrictions only applied to the United States. China was the dominant global producer for many of the materials and many of these materials are on the United States list of critical minerals.

On December 11, the Office of the United States Trade Representative (USTR) announced increases to Section 301 tariff rates on certain tungsten products, with tariffs increasing to 25%, and semiconductor wafers and polysilicon, with tariffs increasing to 50% effective January 1, 2025. On December 30, USTR initiated a Section 301 investigation of China’s acts, policies, and practices related to targeting of the semiconductor industry for dominance. The investigation will focus on manufacturing dominance in foundational logic semiconductors and silicon carbide substrates and other wafers to determine if excess capacity or concentration of production in China has resulted in harm to United States semiconductor producers and foundries.

U.S. Production and Consumption

As shown in figure 1, minerals remained fundamental to the U.S. economy, contributing to the real gross domestic product at several levels, including mining, processing, and manufacturing finished products. The estimated value of nonfuel minerals produced at mines in the United States in 2024 was $106 billion. Domestic raw materials and domestically recycled materials were used to produce mineral materials worth $900 billion. These mineral materials as well as $77 billion of net imports of processed mineral materials were, in turn, consumed by downstream industries creating an estimated value of $4.08 trillion in 2024, a 4% increase from $3.93 trillion (revised) in 2023.

Figure 2 illustrates the reliance of the United States on foreign sources for raw and processed mineral materials. In 2024, imports made up more than one-half of the U.S. apparent consumption for 46 nonfuel mineral commodities, and the United States was 100% net import reliant for 15 of those. Of the 50 mineral commodities identified in the “2022 Final List of Critical Minerals,” the United States was 100% net import reliant for 12, and an additional 28 critical mineral commodities (including 14 lanthanides, which are listed under rare earths) had a net import reliance greater than 50% of apparent consumption.

Figure 3 shows the countries that were sources of nonfuel mineral commodities for which the United States was greater than 50% net import reliant and the number of mineral commodities for which each highlighted country was a leading supplier. China and Canada supplied the largest number of these nonfuel mineral commodities with 21 mineral commodities, each; Germany, 11 mineral commodities; Brazil, 10 mineral commodities; and Japan, Mexico, and South Africa, 7 mineral commodities each.

The estimated value of U.S. metal mine production in 2024 was $33.5 billion, a slight increase from the value in 2023 (table 1). In 2024, the capacity utilization for the metal mining industry remained at 53% after declining for the 4 prior years (table 2). Principal contributors to the total value of metal mine production in 2024 were gold, 35%; copper, 30%; iron ore, 16%; zinc, 7%; and molybdenum, 5%.

The estimated value of U.S. industrial minerals production in 2024, including construction aggregates, was $72.1 billion, unchanged from the revised value in 2023 (table 1). In 2024, the capacity utilization for the nonmetallic minerals mining industry decreased to 85%, compared with 89% capacity utilization in 2023 (table 2). The value of industrial minerals production in 2024 was dominated by crushed stone, 36%; construction sand and gravel, 17%; cement (masonry and portland), 16%; and industrial sand and gravel, 7%.

In 2024, U.S. production of 14 mineral commodities was valued at more than $1 billion each and together the estimated production value accounted for 92% of the total estimated value of production. These commodities were, in decreasing order of value, crushed stone, construction sand and gravel, gold, cement, copper, iron ore, industrial sand and gravel, lime, soda ash, salt, zinc, phosphate rock, molybdenum, and helium.

In 2024, 10 States had more than $3 billion worth of publishable nonfuel mineral commodities production value and another 12 States had more than $1.5 billion (fig. 4). The top 10 producing States (based on total value including withheld values) were, in descending order of production value, Nevada, Texas, Arizona, California, Minnesota, Alaska, Florida, Wyoming, Utah, and Missouri (table 3).

The West was the leading region in the production of metals and metallic minerals; the estimated value was $26 billion in 2024 (fig. 5). The South was the leading region in the production of industrial minerals (excluding construction sand and gravel and crushed stone); the estimated value was $14.5 billion in 2024 (fig. 6).

In 2024, eight States produced more than $1 billion worth of crushed stone. These States were, in descending order of production value, Texas, Florida, Pennsylvania, North Carolina, Georgia, Tennessee, Virginia, and Ohio. There were another eight States with more than $500 million worth of crushed stone production (fig. 7).

Construction sand and gravel was produced in every State. California and Texas each produced more than $1 billion worth of construction sand and gravel in 2024, and Arizona, Washington, and Utah produced more than $500 million. Florida, Colorado, New York, Ohio, and Michigan, in descending order of production value, were the other top 10 producing States (fig. 8).

The Defense Logistics Agency Strategic Materials (DLA Strategic Materials) is responsible for the operational oversight of the National Defense Stockpile (NDS) of strategic and critical materials. Managing the security, providing environmentally sound stewardship, and ensuring the readiness of all NDS stocks is the mission of the DLA Strategic Materials. The NDS currently contains 52 unique commodities stored at nine locations within the continental United States. In fiscal year 2024, the NDS added two materials along with additional quantities of seven other materials, and approximately $37.36 million of excess materials were sold. Revenue from the Stockpile Sales Program funds the operation of the NDS and the acquisition of new stocks. For reporting purposes, NDS stocks are categorized as held in reserve or available for sale. Most stocks are held in reserve. Additional information regarding Annual Material Plans for acquisitions and disposals can be found in the “Government Stockpile” sections in the mineral commodity chapters that follow. Under the authority of the Defense Production Act of 1950 (Public Law 81–774), the USGS advises the DLA Strategic Materials on acquisitions and disposals of NDS mineral materials.

Figure 2.—2024 U.S. Net Import Reliance[1]

Commodity	Net import reliance as a percentage of apparent consumption in 2024	Leading import sources (2020–23)[2]
ARSENIC, all forms	100	China,[3] Morocco, Malaysia, Belgium
ASBESTOS	100	Brazil, Russia
CESIUM	100	Germany, China
FLUORSPAR	100	Mexico, Vietnam, South Africa, China[3]
GALLIUM, metal	100	Japan, China, Germany, Canada
GRAPHITE (NATURAL)	100	China,[3] Canada, Mexico, Mozambique
INDIUM	100	Republic of Korea, Japan, Canada, Belgium
MANGANESE	100	Gabon, South Africa, Australia, Malaysia
MICA (NATURAL), sheet	100	China, Brazil, India
NIOBIUM (COLUMBIUM)	100	Brazil, Canada
RUBIDIUM	100	China, Germany, Russia
SCANDIUM	100	Japan, China, Philippines
STRONTIUM	100	Mexico, Germany
TANTALUM	100	China,[3] Australia, Germany, Indonesia
YTTRIUM, compounds	100	China,[3] Germany
GEMSTONES	99	India, Israel, Belgium, South Africa
ABRASIVES, fused aluminum oxide	>95	China,[3] Canada, Brazil, Austria
NEPHELINE SYENITE	>95	Canada
TITANIUM, sponge metal	>95	Japan, Kazakhstan, Saudi Arabia
POTASH	93	Canada, Russia, Belarus, Israel
BISMUTH, metal, alloys, and scrap	89	China,[3] Republic of Korea
IRON OXIDE PIGMENTS, natural and synthetic	87	China,[3] Germany, Brazil, Canada
TITANIUM MINERAL CONCENTRATES	86	South Africa, Madagascar, Canada, Australia
ANTIMONY, metal and oxide	85	China,[3] Belgium, India, Bolivia
PLATINUM	85	South Africa, Belgium, Germany, Italy
STONE (DIMENSION)	83	Brazil, China,[3] Italy, Turkey
DIAMOND (INDUSTRIAL), stones	81	India, South Africa, Russia, Australia
RARE EARTHS,[4] compounds and metals	80	China,[3] Malaysia, Japan, Estonia
PEAT	78	Canada
CHROMIUM, all forms	77	South Africa, Kazakhstan, Canada, Finland
COBALT, metal, oxides, and salts	76	Norway, Finland, Japan, Canada
BARITE	>75	India, China,[3] Morocco, Mexico
BAUXITE	>75	Jamaica, Turkey, Guyana, Australia
MAGNESIUM METAL	>75	Israel, Canada, Turkey, Czechia
TIN, refined	73	Peru, Bolivia, Indonesia, Brazil
ZINC, refined	73	Canada, Mexico, Republic of Korea, Peru
ABRASIVES, silicon carbide	69	China,[3] Brazil, Canada
RHENIUM	65	Chile, Canada, Germany, Poland
SILVER	64	Mexico, Canada, Republic of Korea, Poland
ALUMINA	59	Brazil, Jamaica, Australia, Canada
MAGNESIUM COMPOUNDS	52	China,[3] Israel, Brazil, Canada
GERMANIUM	>50	Belgium, Canada, China, Germany
IODINE	>50	Chile, Japan
LITHIUM	>50	Chile, Argentina
SELENIUM, metal	>50	Philippines, Mexico, Canada, Poland
TUNGSTEN	>50	China,[3] Germany, Bolivia, Vietnam
SILICON, metal and ferrosilicon	<50	Brazil, Russia, Canada, Malaysia
GARNET (INDUSTRIAL)	48	South Africa, Australia, India, China[3]
NICKEL	48	Canada, Norway, Australia, Brazil
ALUMINUM	47	Canada, United Arab Emirates, Bahrain, China[3]
DIAMOND (INDUSTRIAL), bort, grit, and dust and powder	47	China,[3] Republic of Korea, Ireland, Russia
COPPER, refined	45	Chile, Canada, Mexico, Peru
MICA (NATURAL), scrap and flake	41	China, Canada, India, Finland
VANADIUM	40	Canada, Brazil, Austria, South Africa
PALLADIUM	36	Russia, South Africa, Belgium, Italy
VERMICULITE	34	South Africa, Brazil, Zimbabwe
FELDSPAR	33	Turkey, Mexico
LEAD, refined	28	Canada, Republic of Korea, Mexico, Australia
PERLITE	26	Greece, China
BROMINE	<25	Israel, Jordan, China[3]
TELLURIUM	<25	Canada, Philippines, Japan, Germany
ZIRCONIUM, ores and concentrates	<25	South Africa, Australia, Senegal
SALT	24	Canada, Chile, Mexico, Egypt
CEMENT	22	Turkey, Canada, Vietnam, Greece

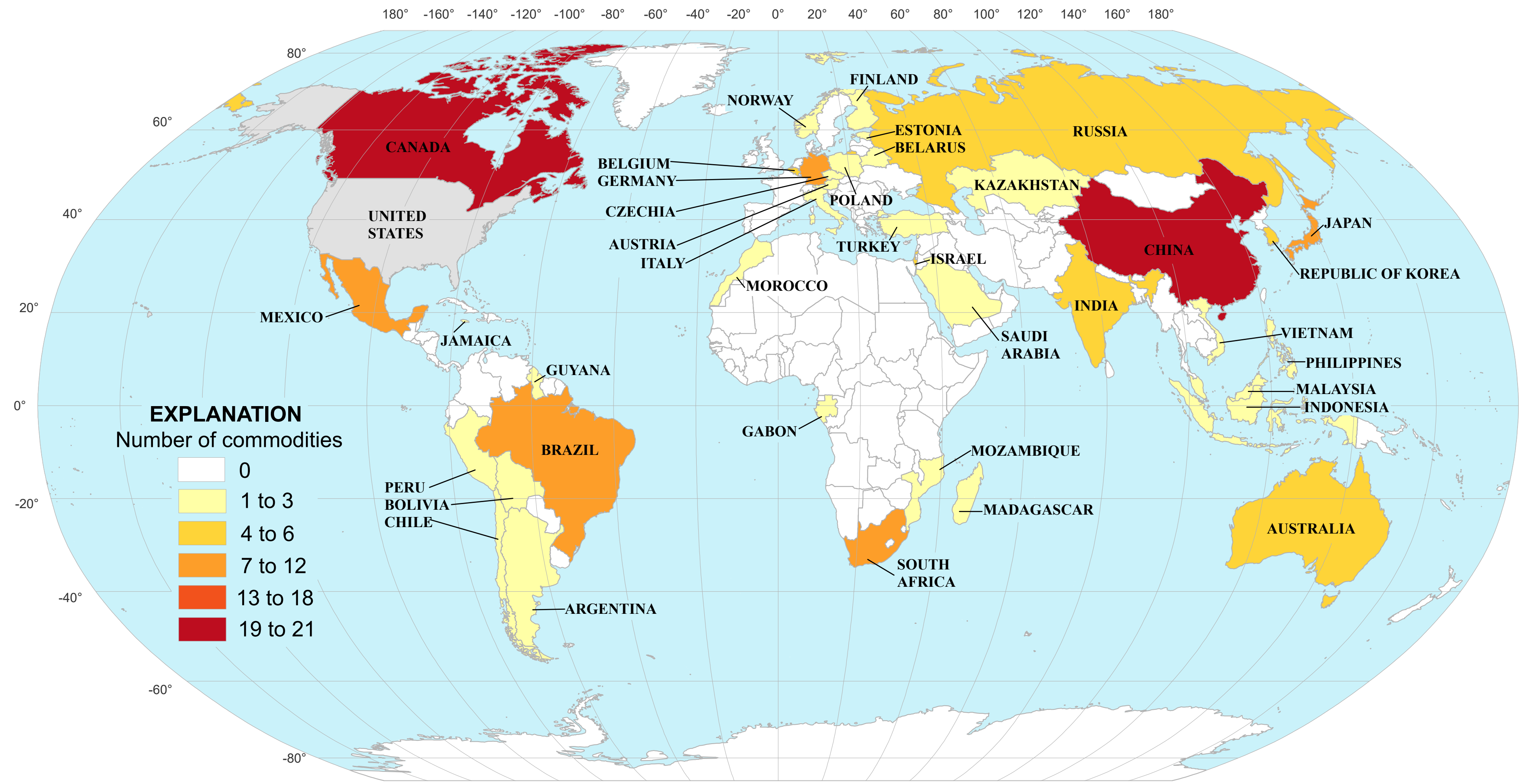
[1]Not all mineral commodities covered in this publication are listed here. Those not shown include mineral commodities for which the United States was a net exporter (abrasives, metallic; beryllium; boron; cadmium; clays; diatomite; gold; helium; iron and steel scrap; iron ore; kyanite; molybdenum; rare earths, mineral concentrates; sand and gravel, industrial; soda ash; titanium dioxide pigment; wollastonite; zeolites; and zinc, ores and concentrates) or less than 20% net import reliant (gypsum; iron and steel; iron and steel slag; lime; nitrogen, fixed—ammonia; phosphate rock; pumice and pumicite; sand and gravel, construction; stone, crushed; sulfur; and talc and pyrophyllite). For some mineral commodities (hafnium; mercury; quartz, high-purity and industrial cultured crystal; thallium; and thorium), available information was inadequate to calculate the exact percentage of import reliance.

[2]Listed in descending order of import share. Only the top four countries are listed. Excludes countries that provided less than 3% import share.

[3]Includes Hong Kong.

[4]Includes lanthanides cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium, samarium, terbium, thulium, and ytterbium.

Figure 3.—Leading Import Sources* (2020–23) of Nonfuel Mineral Commodities for Which the United States Was Greater Than 50% Net Import Reliant



Source: U.S. Geological Survey

*Countries as listed in figure 2.

Table 1.—U.S. Mineral Industry Trends

	2020	2021	2022	2023	2024[e]
Total mine production (million dollars):					
Metals	28,100	36,800	35,200	33,000	33,500
Industrial minerals	54,100	58,900	67,700	72,100	72,100
Coal	16,800	21,000	32,300	31,200	27,500
Employment (thousands of workers):					
Coal mining, all employees	40	38	41	43	43
Nonfuel mineral mining, all employees	136	139	142	144	150
Chemicals and allied products, production workers	537	541	567	563	570
Stone, clay, and glass products, production workers	296	300	312	305	300
Primary metal industries, production workers	272	269	283	291	280
Average weekly earnings of workers (dollars):					
Coal mining, all employees	1,519	1,617	1,756	1,826	2,000
Chemicals and allied products, production workers	1,065	1,102	1,118	1,230	1,300
Stone, clay, and glass products, production workers	981	1,018	1,086	1,127	1,100
Primary metal industries, production workers	1,007	1,074	1,170	1,211	1,200

[e]Estimated.

Sources: U.S. Geological Survey, U.S. Department of Energy, and U.S. Department of Labor.

Table 2.—U.S. Mineral-Related Economic Trends

	2020	2021	2022	2023	2024[e]
Gross domestic product (billion dollars)	21,354	23,681	26,007	27,721	29,179
Industrial production (2017=100):					
Total index:	95	99	103	103	100
Manufacturing:	93	98	100	100	100
Nonmetallic mineral products	97	101	107	106	100
Primary metals:	87	96	95	95	94
Iron and steel	87	102	96	97	93
Aluminum	92	97	96	91	94
Nonferrous metals (except aluminum)	92	95	105	108	110
Chemicals	95	100	102	104	110
Mining:	103	106	114	120	120
Coal	69	75	77	76	67
Oil and gas extraction	123	123	131	141	140
Metals	95	92	86	80	80
Nonmetallic minerals	99	104	107	105	100
Capacity utilization (percent):					
Total industry:	73	78	81	79	78
Mining:	72	82	90	90	89
Metals	66	62	56	53	53
Nonmetallic minerals	84	87	90	89	85
Housing starts (thousands)	1,394	1,605	1,552	1,421	1,350
Light vehicle sales (thousands)	14,472	14,947	13,754	15,502	15,600
Highway construction, value, put in place (billion dollars)	103	104	115	138	140

[e]Estimated.

Sources: U.S. Department of Commerce and Federal Reserve Board.

Table 3.—Value of Nonfuel Mineral Production in the United States and Principal Nonfuel Mineral Commodities Produced in 2024[p, 1, 2]

State	Value (millions)	Rank[3]	Percent of U.S. total[4]	Principal nonfuel mineral commodities[5]
Alabama	$2,210	16	2.1	Cement, lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Alaska	4,710	6	4.46	Gold, lead, sand and gravel (construction), silver, zinc.
Arizona	9,290	3	8.79	Cement, copper, molybdenum mineral concentrates, sand and gravel (construction), stone (crushed).
Arkansas	1,140	29	1.08	Bromine compounds, cement, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
California[6]	5,480	4	5.19	Boron minerals, cement, gold, sand and gravel (construction), stone (crushed).
Colorado	2,050	18	1.94	Cement, gold, molybdenum mineral concentrates, sand and gravel (construction), stone (crushed).
Connecticut[7]	259	43	0.25	Sand and gravel (construction), stone (crushed), stone (dimension).
Delaware[7]	27	50	0.03	Magnesium compounds, sand and gravel (construction), stone (crushed).
Florida[6, 7]	3,060	7	2.9	Cement, phosphate rock (marketable), sand and gravel (construction), stone (crushed).
Georgia[6]	2,700	13	2.56	Cement, clay (attapulgite, common clay, kaolin, montmorillonite), sand and gravel (construction), stone (crushed).
Hawaii	175	47	0.17	Sand and gravel (construction), stone (crushed).
Idaho[7]	543	33	0.51	Phosphate rock (marketable), sand and gravel (construction), silver, stone (crushed), zinc.
Illinois	1,470	25	1.39	Cement (portland), magnesium compounds, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Indiana	1,590	22	1.51	Cement, lime, sand and gravel (construction), stone (crushed), stone (dimension).
Iowa	730	36	0.69	Cement (portland), lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Kansas[7]	811	27	0.77	Cement, helium (grade-a), salt, sand and gravel (construction), stone (crushed).
Kentucky[7]	874	28	0.83	Cement (portland), clay [common clay and (or) shale], lime, sand and gravel (construction), stone (crushed).
Louisiana[7]	846	32	0.8	Lime, salt, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Maine[7]	167	46	0.16	Cement, peat, sand and gravel (construction), stone (crushed), stone (dimension).
Maryland[7]	435	34	0.41	Cement, sand and gravel (construction), stone (crushed), stone (dimension).
Massachusetts[7]	412	39	0.39	Clay [common clay and (or) shale], lime, sand and gravel (construction), stone (crushed), stone (dimension).
Michigan	3,080	11	2.92	Cement, iron ore, magnesium compounds, sand and gravel (construction), stone (crushed).
Minnesota[7]	4,830	5	4.58	Iron ore, lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Mississippi[7]	196	42	0.19	Clay (ball clay, bentonite, common clay, montmorillonite), sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Missouri	3,160	10	2.99	Cement, lead, lime, sand and gravel (industrial), stone (crushed).
Montana	1,130	30	1.07	Cement, copper, molybdenum mineral concentrates, palladium metal, sand and gravel (construction).

See footnotes at end of table.

Table 3.—Value of Nonfuel Mineral Production in the United States and Principal Nonfuel Mineral Commodities Produced in 2024[p, 1, 2]—Continued

State	Value (millions)	Rank[3]	Percent of U.S. total[4]	Principal nonfuel mineral commodities[5]
Nebraska[7]	$137	40	0.13	Cement (portland), lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Nevada	9,970	1	9.44	Copper, diatomite, gold, sand and gravel (construction), silver.
New Hampshire[7]	206	45	0.2	Sand and gravel (construction), stone (crushed), stone (dimension).
New Jersey[7]	536	38	0.51	Peat, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
New Mexico	1,530	23	1.45	Cement, copper, potash, sand and gravel (construction), stone (crushed).
New York[7]	1,800	19	1.71	Cement, salt, sand and gravel (construction), stone (crushed), zinc.
North Carolina	2,720	12	2.57	Phosphate rock (marketable), quartz (high-purity), sand and gravel (construction), sand and gravel (industrial), stone (crushed).
North Dakota[7]	84	48	0.08	Clay [common clay and (or) shale], lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Ohio	2,230	15	2.11	Cement, lime, salt, sand and gravel (construction), stone (crushed).
Oklahoma	1,360	26	1.29	Cement, iodine (crude), sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Oregon[7]	493	35	0.47	Cement (portland), diatomite, perlite (crude), sand and gravel (construction), stone (crushed).
Pennsylvania[7]	2,410	14	2.28	Cement, lime, sand and gravel (construction), stone (crushed).
Rhode Island[7]	100	49	0.09	Sand and gravel (construction), sand and gravel (industrial), stone (crushed).
South Carolina	1,920	20	1.82	Cement, gold, sand and gravel (construction), stone (crushed).
South Dakota[7]	389	37	0.37	Cement (portland), gold, lime, sand and gravel (construction), stone (crushed).
Tennessee	2,080	17	1.97	Cement, sand and gravel (construction), sand and gravel (industrial), stone (crushed), zinc.
Texas	9,720	2	9.2	Cement, lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Utah	3,520	9	3.33	Cement (portland), copper, potash, salt, sand and gravel (construction).
Vermont[7]	209	44	0.2	Sand and gravel (construction), stone (crushed), stone (dimension), talc (crude).
Virginia	1,770	21	1.67	Cement, kyanite, lime, sand and gravel (construction), stone (crushed).
Washington	929	31	0.88	Cement, diatomite, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
West Virginia[7]	238	41	0.23	Cement, lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed).
Wisconsin[7]	1,360	24	1.29	Lime, sand and gravel (construction), sand and gravel (industrial), stone (crushed), stone (dimension).
Wyoming[7]	622	8	0.59	Cement, clay (bentonite and common clay), helium (grade-a), sand and gravel (construction), soda ash.
Undistributed	7,910	XX	7.49	XX.
Total	106,000	XX	100.00	

[p]Preliminary. XX Not applicable.

[1]Includes data available through December 17, 2024.

[2]Data are rounded to no more than three significant digits; may not add to totals shown.

[3]Rank based on total, unadjusted State values.

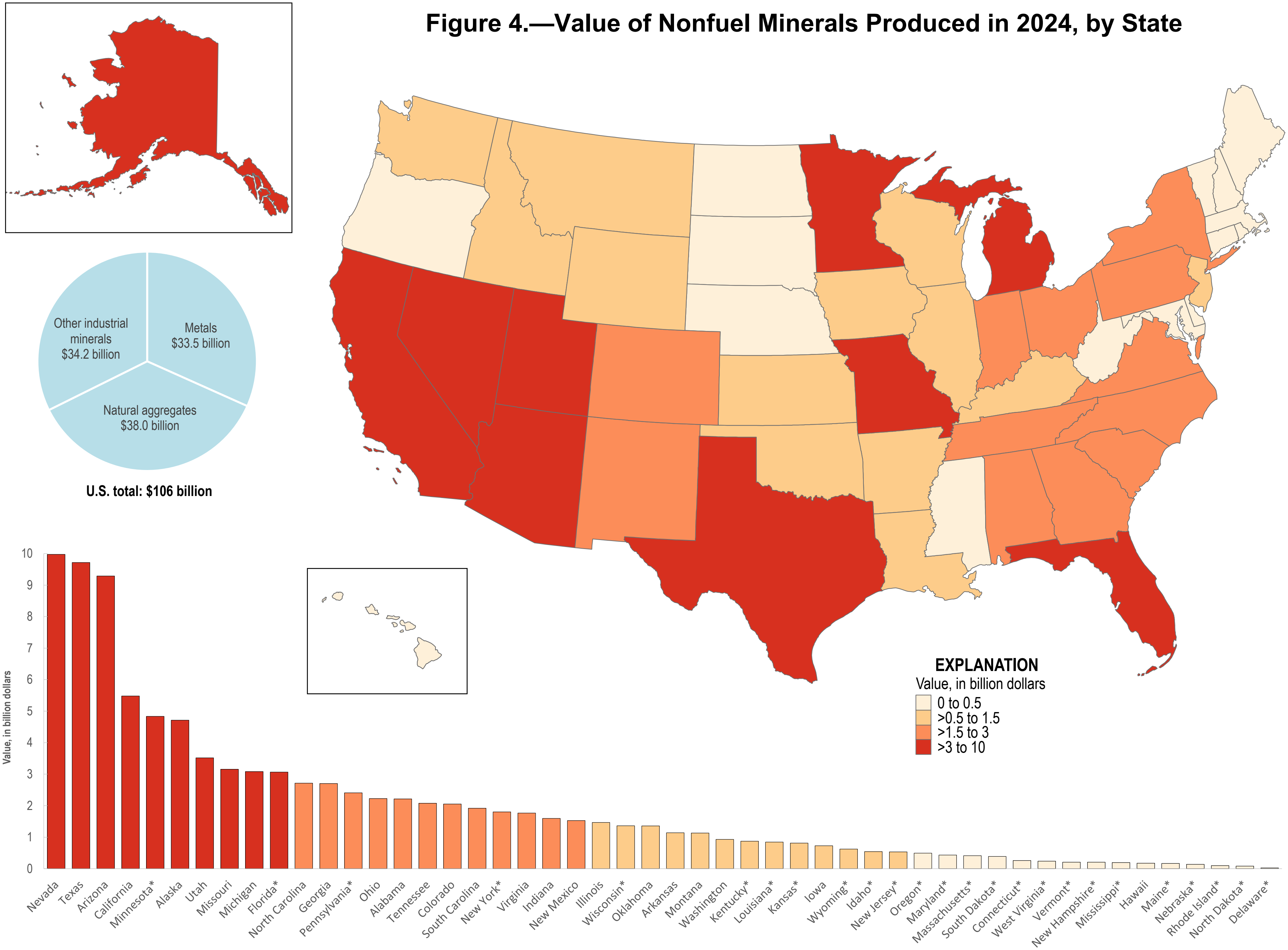
[4]"Percent of U.S. total" calculated to two decimal places.

[5]Listed in alphabetical order.

[6]California, Florida, and Georgia also produced significant quantities of titanium mineral concentrates and zirconium mineral concentrates. Breakdown by State is not available to avoid disclosure of company proprietary data.

[7]Partial total; excludes values that must be withheld to avoid disclosing company proprietary data, which are included with "Undistributed."

Figure 4.—Value of Nonfuel Minerals Produced in 2024, by State



*Partial total; excludes values that must be withheld to avoid disclosing company proprietary data, which are included with "Undistributed" in table 3.

Figure 5.—Value of Metals and Metallic Minerals Produced in 2024, by Region

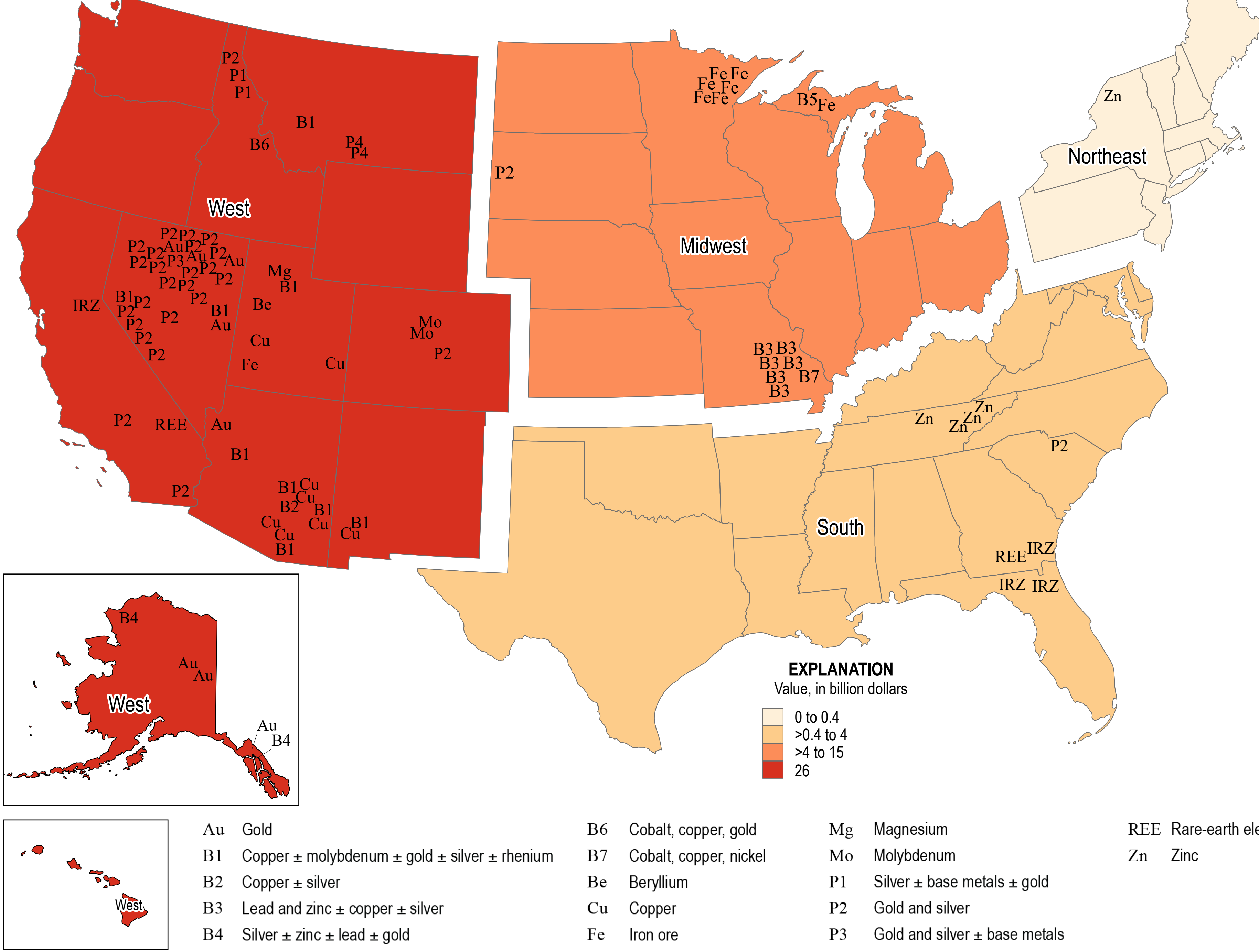
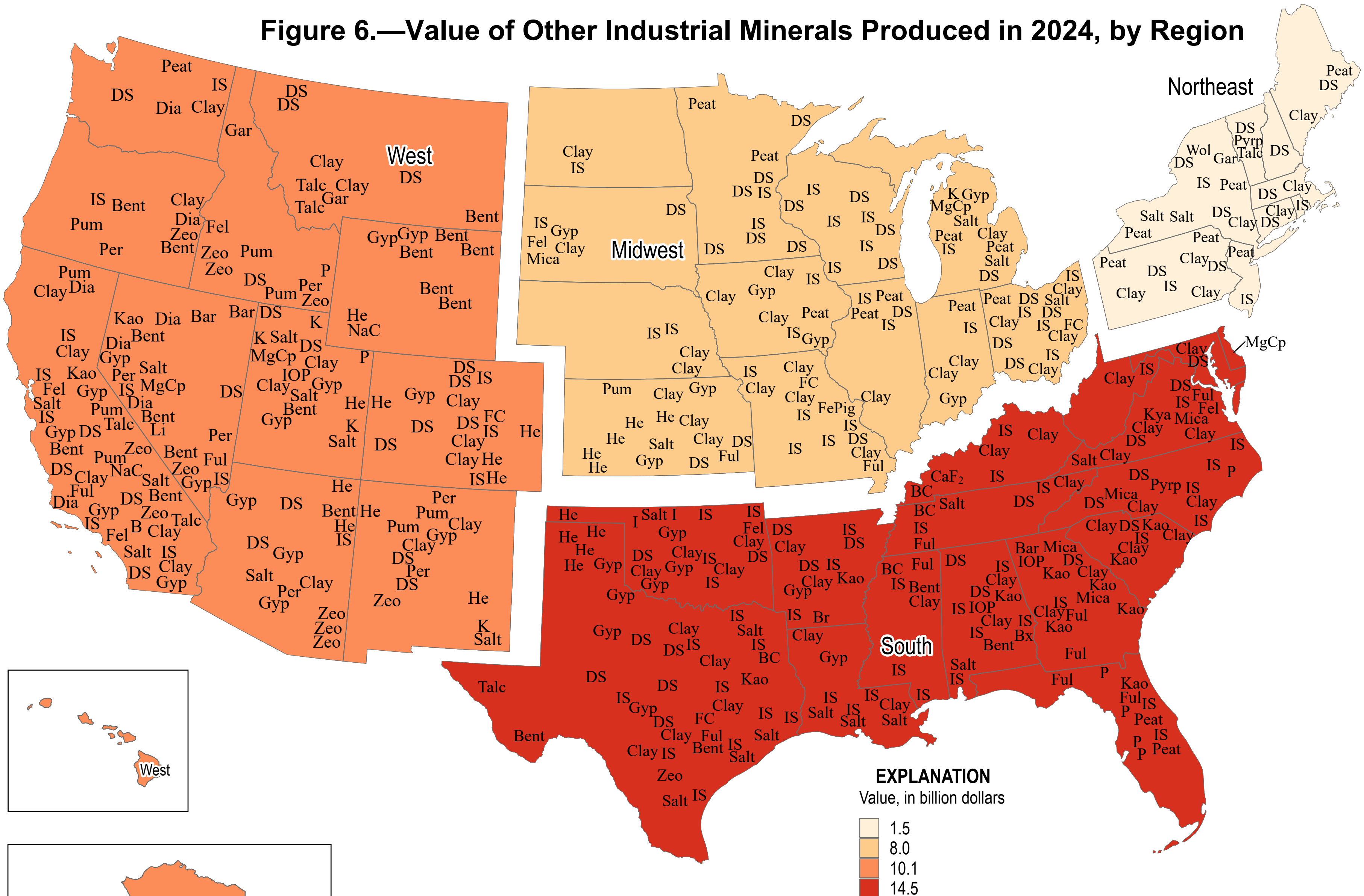
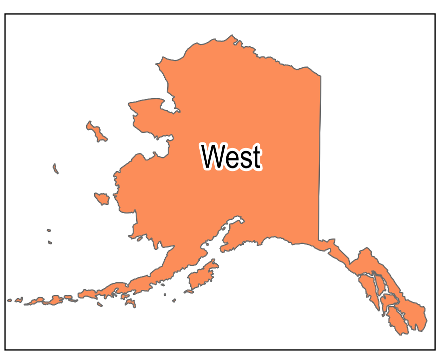


Figure 6.—Value of Other Industrial Minerals Produced in 2024, by Region





B	Borates	Clay	Common clay	Gyp	Gypsum	Kya	Kyanite	Per	Perlite
Bar	Barite	Dia	Diatomite	He	Helium	Li	Lithium	Pum	Pumice
BC	Ball clay	DS	Dimension stone	I	Iodine	MgCp	Magnesium compounds	Pyrp	Pyrophyllite
Bent	Bentonite	FC	Fire clay	IOP	Iron oxide pigments	Mica	Mica	Salt	Salt
Br	Bromine	Fel	Feldspar	IS	Industrial sand	NaC	Soda ash	Talc	Talc
Bx	Bauxite	Ful	Fuller's earth	K	Potash	P	Phosphate rock	Wol	Wollastonite
CaF_2	Fluorspar	Gar	Garnet	Kao	Kaolin	Peat	Peat	Zeo	Zeolites

Figure 7.—Value of Crushed Stone Produced in 2024, by State

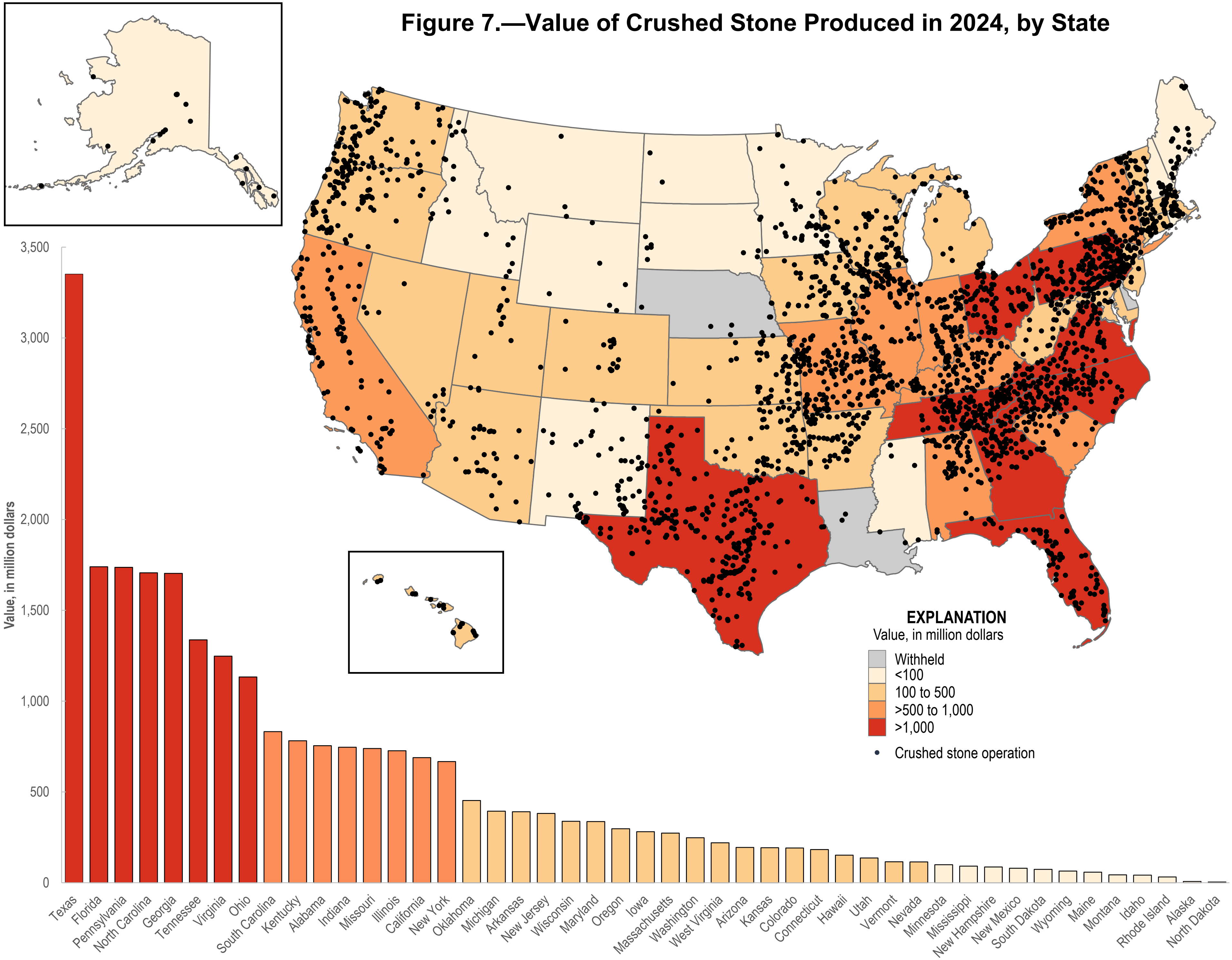


Figure 8.—Value of Construction Sand and Gravel Produced in 2024, by State

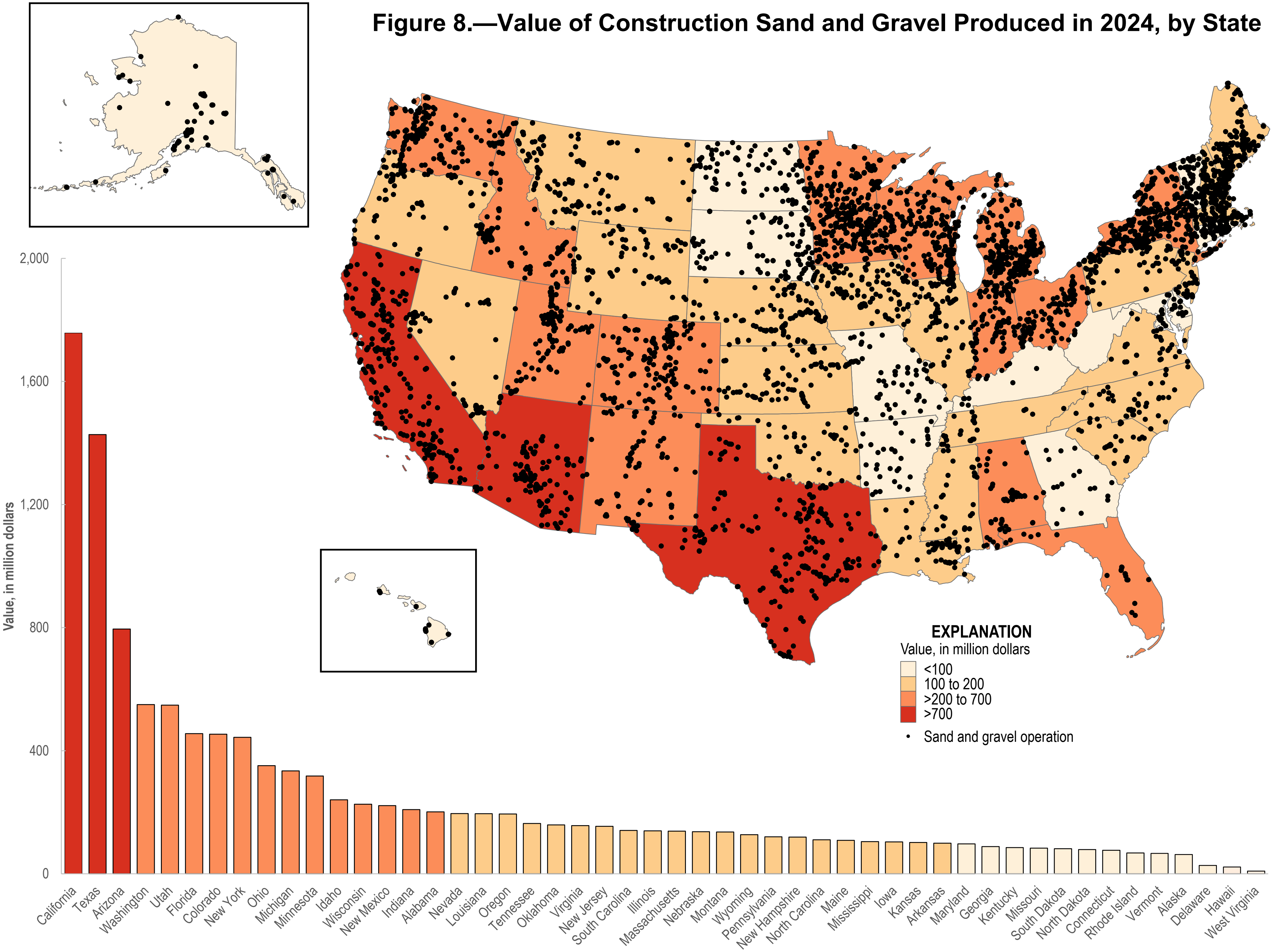


Table 4.—The 2022 U.S. Critical Minerals List[1]

Critical mineral	Applications
Aluminum	Metallurgy and many sectors of the economy.
Antimony	Flame retardants and lead-acid batteries.
Arsenic	Pesticides and semiconductors.
Barite	Hydrocarbon production.
Beryllium	Aerospace and defense.
Bismuth	Medical, metallurgy, and atomic research.
Cerium[2]	Catalytic converters, ceramics, glass, metallurgy, and polishing compounds.
Cesium	Research and development.
Chromium	Metallurgy.
Cobalt	Batteries and metallurgy.
Dysprosium[2]	Data storage devices, lasers, and permanent magnets.
Erbium[2]	Fiber optics, glass colorant, lasers, and optical amplifiers.
Europium[2]	Nuclear control rods and phosphors.
Fluorspar	Cement, industrial chemicals, and metallurgy.
Gadolinium[2]	Medical imaging, metallurgy, and permanent magnets.
Gallium	Integrated circuits and optical devices.
Germanium	Defense and fiber optics.
Graphite	Batteries, fuel cells, and lubricants.
Hafnium	Ceramics, nuclear control rods, and metallurgy.
Holmium[2]	Lasers, nuclear control rods, and permanent magnets.
Indium	Liquid crystal displays.
Iridium[3]	Anode coatings for electrochemical processes and chemical catalysts.
Lanthanum[2]	Batteries, catalysts, ceramics, glass, and metallurgy.
Lithium	Batteries.
Lutetium[2]	Cancer therapies, electronics, and medical imaging.
Magnesium	Metallurgy.
Manganese	Batteries and metallurgy.
Neodymium[2]	Catalysts, lasers, and permanent magnets.
Nickel	Batteries and metallurgy.
Niobium	Metallurgy.
Palladium[3]	Catalytic converters and catalysts.
Platinum[3]	Catalytic converters and catalysts.
Praseodymium[2]	Aerospace alloys, batteries, ceramics, colorants, and permanent magnets.
Rhodium[3]	Catalytic converters, catalysts, and electrical components.
Rubidium	Research and development.
Ruthenium[3]	Catalysts, electronic components, and computer chips.
Samarium[2]	Cancer treatments, nuclear, and permanent magnets.
Scandium	Ceramics, fuel cells, and metallurgy.
Tantalum	Capacitors and metallurgy.
Tellurium	Metallurgy, solar cells, and thermoelectric devices.
Terbium[2]	Fiber optics, lasers, permanent magnets, and solid state devices.
Thulium[2]	Lasers and metallurgy.
Tin	Metallurgy.
Titanium	Metallurgy and pigments.
Tungsten	Metallurgy.
Vanadium	Batteries, catalysts, and metallurgy.
Ytterbium[2]	Catalysts, lasers, metallurgy, and scintillators.
Yttrium	Catalysts, ceramics, lasers, metallurgy, and phosphors.
Zinc	Metallurgy.
Zirconium	Metallurgy and nuclear.

[1]The 2022 Final List of Critical Minerals published February 24, 2022, by the U.S. Geological Survey (87 FR 10381).

[2]Included in the Rare Earths chapter.

[3]Included in the Platinum-Group Metals chapter.

U.S. CRITICAL MINERALS UPDATE

The United States List of Critical Minerals

On February 24, 2022, pursuant to section 7002 of the Energy Act of 2020 (Public Law 116–260) and using the definition of "critical mineral" and the criteria specified therein, the U.S. Geological Survey (USGS) published the "2022 Final List of Critical Minerals" in the Federal Register (87 FR 10381). The 2022 list of critical minerals, which revised the U.S. list of critical minerals published in 2018 (83 FR 23295), included 50 mineral commodities instead of 35 mineral commodities or mineral groups (table 4). The changes in the 2022 Final List of Critical Minerals from the 2018 list were the addition of nickel and zinc, listing out individual platinum-group metals (excluding osmium) and rare-earth elements, and the removal of helium, potash, rhenium, strontium, and uranium. The list of critical minerals is to be updated at least every 3 years and revised as necessary consistent with available data.

Background

A series of actions by the Government in recent years addressed domestic supply chain vulnerabilities for critical minerals, beginning with Executive Order 13817, "A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals," which was issued on December 26, 2017, and initiated a whole-of-Government call to action to identify critical minerals and develop a strategy to address U.S. supply-chain vulnerabilities. Subsequently, there have been additional actions including the following:

1. The USGS published the 2018 List of Critical Minerals;
2. The U.S. Department of Commerce with interagency input published the "2019 Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals";
3. Several Presidential determinations directed the use of Defense Production Act (DPA) title III authorities to strengthen the U.S. industrial base for rare-earth elements;
4. Executive Order 13953 was issued "Addressing the Threat to the Domestic Supply Chain Reliance on Critical Minerals from Foreign Adversaries and Supporting the Domestic Mining and Processing Industries"; and
5. The Energy Act of 2020 was passed by Congress and signed into law.

Several congressional acts and other Government actions have focused on investments for clean energy projects; critical mineral mapping, production, recycling, reclamation, and resource assessments; domestic production of batteries; infrastructure projects; research and development; ports and rail improvements; semiconductor supply-chain projects; telecommunications broadband networks; and water systems. These actions have included the following:

1. Congress passed and the President signed the $1.2 trillion Bipartisan Infrastructure Law (Infrastructure Investment and Jobs Act, H.R. 3684, Public Law 117–58) in November 2021;
2. A Presidential determination on March 31, 2022, authorized the use of DPA Title III authorities to strengthen the U.S. industrial base for large-capacity batteries and specifically to increase domestic mining and processing of critical materials such as cobalt, graphite, lithium, and nickel for the large-capacity battery supply chain;
3. The Ukraine Supplemental Appropriations Act of 2022 provided $600 million for DPA Title III funds for missiles and munitions in support of Ukraine and for strategic and critical materials to expand domestic capacity;
4. The CHIPS and Science Act of 2022 (Public Law 117–167) provided $280 billion in funding over the next 10 years for domestic research, commercialization, and manufacturing of semiconductors;
5. The Inflation Reduction Act of 2022 (Public Law 117–169) was signed into law with the aim to reduce inflation. Specifically related to critical minerals, it authorized $391 billion in funding for domestic renewable energy production including targeted tax incentives aimed at manufacturing U.S.-sourced materials such as batteries, electric vehicles (EVs), solar, and wind energy parts and technologies;
6. In October 2022, the "American Battery Materials Initiative" was launched to leverage and maximize ongoing efforts throughout the U.S. Government to meet resource requirements and bolster energy security;
7. In December 2022, the $858 billion National Defense Authorization Act included a provision requiring that a Federal strategy be developed to recycle and recover critical minerals from batteries used in the Federal EV fleet; and
8. In July 2023, the Department of Energy (DOE) published its 2023 DOE Critical Materials list of energy-specific critical and near-critical materials for clean energy technology supply chains.

Critical Minerals Investments in 2024

In 2024, the Department of Defense (DoD) through the Defense Production Act Investments program took actions to establish domestic manufacturing capabilities for critical minerals and awarded a total of more than $400 million to U.S.-based projects. These investments included developing or expanding domestic production capabilities for aluminum, magnesium, tin, titanium powder, and zirconium powder for many industrial and defense applications; cobalt, graphite, lithium carbonate, battery-grade manganese, and nickel for the production of batteries; germanium substrates used in solar cells for defense and commercial satellites; high-purity niobium oxide for electronics; and terbium oxide and other rare-earth elements for permanent magnets and other applications.

The Defense Production Act program has considered Canada as a domestic source for funds since 1992 and, in 2024, the DoD announced awards of more than $40 million to Canadian companies to help support the United States-Canada Joint Action Plan on Critical Minerals. These awards will help build resilience in the cobalt and graphite supply chains and are in accordance with the 2024 National Defense Industrial Strategy to continue and expand support for domestic production of critical minerals.

In 2024, the DOE through the Bipartisan Infrastructure Law announced $4.82 billion in funding for 39 projects to support domestic production of advanced batteries and battery materials nationwide in two rounds of funding. The grants awarded in round 1 were for projects for building and expanding commercial-scale facilities for lithium, graphite, and other materials for battery-component and battery manufacturing. Projects selected for round 2, which were still undergoing final approval at yearend, were for increasing battery production nationwide and new approaches to component manufacturing and recycling. Additionally, funding was announced for projects that will support the design and construction of facilities that produce and refine rare-earth elements and other critical minerals and materials from coal-based resources and other recycled materials.

During fiscal year 2023, the DOE's Loan Programs Office completed two loan transactions totaling over $5 billion, including a loan for a lithium-ion battery recycling facility. There were also seven prospective projects being evaluated totaling nearly $14 billion of requested loans, including for lithium carbonate, battery recycling, and battery production facilities.

In January, the National Renewable Energy Laboratory, administrator of the 3-year Cadmium Telluride Photovoltaics Accelerator program, announced that $1.8 million had been awarded in a second round of contracts to support development of cadmium-telluride (CdTe) solar cells that would be more efficient and have a lower cost.

In March, the DOE, the U.S. Department of the Treasury, and the Internal Revenue Service announced $4 billion in tax credits for more than 100 projects across 35 States to accelerate domestic renewable energy manufacturing and reduce greenhouse gas emissions at industrial facilities under the Inflation Reduction Act. Of the $4 billion in tax credits, $1.5 billion supports projects in historical energy communities. It was reported that the private sector has made more than $120 billion in investments in the EV supply chain.

As of December 2024, the U.S. Department of Commerce announced that preliminary agreements had been made with 27 companies for 40 semiconductor manufacturing projects in 21 States since the CHIPS and Science Act was signed into law in 2022. In total, these projects have been awarded almost $34 billion of the available $39 billion in direct funding and almost $29 billion in loans. Companies in the semiconductor supply chain were reported to have invested almost $450 billion since the CHIPS and Science Act was passed.

Critical Minerals Facilities

In January, a primary aluminum smelter in Missouri with a capacity of 263,000 tons per year ceased operations. There were no plans for restarting the operation.

In February, a company began commercial production of spherical graphite in Vidalia, LA. The facility had an initial capacity of 11,300 tons per year.

In April, the West Virginia Department of Environmental Protection through funding from the DOE and the U.S. Department of the Interior's Office of Surface Mining Reclamation and Enforcement began operations at the Richard Mine acid mine drainage (AMD) treatment plant in Monongalia County, WV. The facility treats AMD using a process developed by the University of West Virginia's Water Research Institute that allows for the collection of light- and heavy-rare-earth concentrate before the cleaned drainage is released into Deckers Creek.

In December, a company announced that a flotation plant was delivered to its fluorspar mine in Utah and would enable domestic production of acid-grade fluorspar (also called acidspar) with commissioning expected in 2025.

The leading domestic CdTe solar panel manufacturer, based in Ohio, began commercial production in the third quarter of 2024 at a fourth facility, located in Alabama, that increased solar panel manufacturing capacity to almost 11 gigawatts per year (GW/yr). A fifth site was under construction in Louisiana and was expected to add another 3.5 GW/yr in the second half of 2025. Worldwide, the company's capacity was about 21 GW/yr including a facility in India that opened in early 2024.

One plant in Ohio that processed cobalt and nickel scrap started commercial production of nickel-cobalt intermediate products in 2024.

Owing to low prices and oversupplied market conditions in 2024, a cobalt mine in Idaho remained on care-and-maintenance status, lithium production from the brine-sourced waste tailings of a Utah-based magnesium producer was idled, a platinum-group-metals (PGMs) producer in Montana reduced production, and vanadium production remained suspended in Utah.

Around the world, oversupply of stainless steel in China caused the price for ferrochromium to drop; price decreases in palladium have disrupted the PGM market with mine closures and layoffs, especially in South Africa; and lower vanadium prices hindered development of vanadium and its products because China is the leading vanadium electrolyte producer, and it dominated the vanadium redox flow battery market.

In January 2024, three nickel mines located in Western Australia, Australia, announced closures and other operations in Western Australia were put on care-and-maintenance status. Companies cited oversupply in the global cobalt and nickel markets and low cobalt and nickel prices. In 2024, cobalt mine production increased by 47% in Indonesia and by 26% in Congo (Kinshasa), which was predominantly shipped to China for processing. China announced increases in cobalt refinery capacity in 2024, almost doubling its metal capacity from that in 2023.

Foreign Trade

In December 2024, China implemented export bans on antimony, gallium, and germanium, expanding existing export restrictions that were put in place in December 2023 on certain strategic materials and technologies in the “Catalogue of Technologies Prohibited and Restricted from Export in China.” Export restrictions only applied to the United States. Those items under an export ban included a category called “Nonferrous Metal Smelting and Processing Industry” that had export restrictions that required exporters to apply for a license, which required export contracts, technical product specifications, and the identity of the end user, as well as the specific end use. Restrictions applied to items including rare-earth extraction and separation technology, rare-earth magnets and rare-earth compounds, and rare-earth mining, mineral processing, and smelting technologies; preparation technologies for single-crystal materials; lithium tetraborate and lithium triborate crystal technology as well as several other crystal growth processes; beryllium material preparation; flake graphite, spherical graphite (natural and synthetic), expandable graphite, and some synthetic graphite products; and superalloys for aviation. China was the dominant global producer for many critical mineral materials, and many of the materials were on United States list of critical minerals. See the “Significant Events, Trends, and Issues” section beginning on page 5 for more details on trade actions.

U.S. Geological Survey Earth Mapping Resources Initiative for Critical Minerals

The USGS Earth Mapping Resources Initiative (Earth MRI) is a collaborative project between the USGS and State geological surveys to collect and modernize the Nation’s geologic mapping and data resources. In 2024, the USGS invested millions of dollars to strengthen domestic supply chains for mineral commodities that are critical to every economic sector. The flagship effort within these investments is a nationwide mapping effort for critical minerals, which has been expanded and accelerated by funding from the Bipartisan Infrastructure Law. The USGS is improving the understanding of resources of these minerals, in the ground and in mine waste, across the Nation through Earth MRI. In fiscal year 2024 alone, the USGS distributed more than $57 million across 39 States to fund geoscience data collection and mapping in partnership with State geological surveys, data preservation programs, and scientific interpretation efforts to identify areas of the country with potential for the occurrence of critical minerals. Funding from approximately $51 million of the overall $57 million was part of the broader $510.7 million investment in the USGS from the Bipartisan Infrastructure Law to support scientific innovation.

In 2024, priority areas for new data collection were guided by the “National Map of Focus Areas for Potential Critical Mineral Resources in the United States” (USGS Fact Sheet 2023–3007). Mapping of focus areas was based on a framework of mineral systems and their associated mineral deposit types that could possibly contain critical minerals. Knowledge gained by mapping these focus areas will be used to guide future efforts to collect new geologic, geophysical, geochemical, and topographic data through Earth MRI.

A significant part of Earth MRI’s activity in 2024 involved partnerships with State geological surveys across the Nation. State geological surveys conducted new geologic mapping and reconnaissance geochemical surveys that provided insights into critical mineral focus areas. State geological surveys contributed directly to USGS efforts to inventory and characterize mine waste at legacy and active sites, and they also were offered Earth MRI funding to preserve vital geologic data and samples through the USGS National Geological and Geophysical Data Preservation Program (NGGDPP). In 2024, Earth MRI funded 22 new geologic or reconnaissance geochemical mapping projects through cooperative agreements with 25 different State geological surveys, and 14 State geological surveys were funded for mine waste inventory and (or) characterization projects. Fifteen States were funded for critical mineral data preservation through the NGGDPP, and every dollar awarded through this program was matched by the State geological surveys. In total, more than $12 million was invested by Earth MRI directly into State geological surveys in 2024, with most of the funding (approximately 79%) provided by the Bipartisan Infrastructure Law.

Airborne magnetic and radiometric surveys.—In 2024, more than $40 million was invested to collect new, high-resolution airborne magnetic and radiometric geophysical data in multiple regions of the United States to aid in bedrock geologic mapping and modeling of regions prospective for the occurrence of critical mineral resources. New airborne geophysical surveys funded in Alaska continued data collection across the Kuskokwim Mountains region in the southwestern part of the State, which may contain resources of antimony, gold, rare-earth elements, tin, and tungsten and has high favorability for the occurrence of undiscovered resources of other minerals. In the Western United States, magnetic-radiometric surveys funded in 2024 covered an area greater than 102,000 square kilometers (39,700 square miles) in parts of Colorado, Idaho, Montana, Nevada, New Mexico, western Texas, and Wyoming. Companion geologic mapping, reconnaissance geochemical mapping, and mine waste investigations were also started in many of these States. When completed, these and previously funded surveys will cover and connect with active Earth MRI geophysical surveys in northern Colorado and southern Wyoming, providing new insights into multiple mineral systems in the region. New surveys in Idaho and Montana bridged active surveys focused on the Pioneer batholith to the east and Idaho cobalt belt to the west. New airborne magnetic-radiometric data collection in Nevada will cover approximately 22,200 square kilometers (8,570 square miles) of the east-central part of the State. Survey targets include Carlin, porphyry copper, reduced intrusion-related, and lacustrine evaporite mineral systems which may contain critical minerals such as antimony, beryllium, lithium, tellurium, tin, and tungsten.

In the central United States, a new airborne magnetic-radiometric survey spans more than 79,700 square kilometers (30,800 square miles) of central Missouri and adjacent parts of northern Arkansas and eastern Kansas to investigate basin-brine path and marine chemocline mineral systems. These systems underlie historical mining districts and encompass areas that may contain rare-earth elements. Another new geophysical survey was initiated over parts of southeastern Nebraska and northeastern Kansas, focused on mapping buried crystalline rocks related to the Precambrian Midcontinent Rift System and the Paleozoic Elk Creek carbonatite. In the north-central United States, two new surveys focused on a region around Sioux Falls, SD, and on the Upper Peninsula of Michigan and northern Wisconsin. The Sioux Falls survey builds on a larger regional survey started in 2022. The new survey in northern Michigan covers a large region of variably exposed Precambrian rocks that may host graphite, nickel, and platinum-group elements, in addition to many other critical mineral commodities.

In the Eastern United States, two major airborne magnetic-radiometric surveys were initiated in 2024. A new survey covering parts of Connecticut, Massachusetts, New Hampshire, Rhode Island, and Vermont investigated mineral systems and geologic provinces that may host cobalt, graphite, lithium, nickel, and tin deposits. The survey was also designed to aid in mapping the distribution of rocks containing pyrrhotite, a sulfide mineral that is common in the region and presents infrastructure challenges when incorporated into concrete. In the Southeastern United States, a new survey extends from the coastal plain of North Carolina across the Piedmont and Appalachian Mountains of Virginia and West Virginia. The survey will cover prospective heavy-mineral-sand deposits enriched in rare-earth elements, titanium, and zirconium that are common throughout the coastal plain and are being mapped in greater detail using active and completed Earth MRI magnetic-radiometric surveys. The survey will also cross historical mining districts and mineral systems in the Appalachian Mountains that may host deposits of barite, chromium, cobalt, manganese, tin, tungsten, and zinc.

Airborne electromagnetic surveys.—In 2024, approximately $3 million was invested in regional and small-scale airborne electromagnetic (AEM) surveys in the Western and Central United States. Two multiyear survey efforts began in Wyoming and Michigan. The Wyoming AEM survey began in the southern part of the State and focused on the Cheyenne Belt. The AEM survey in the Upper Peninsula of Michigan will aid mapping and modeling of Precambrian graphite-bearing strata in the region in addition to mafic magmatic rocks associated with the Midcontinent Rift System that contain cobalt, nickel, and platinum-group elements. The Michigan AEM survey will also be optimized in selected areas to facilitate groundwater modeling in support of Tribes in the region. A focused AEM survey was conducted around Dubuque, IA, to investigate phosphate-rich strata that underlie portions of Illinois, Iowa, and Wisconsin. The survey area covers a phosphate horizon in Ordovician shale that is enriched in rare-earth elements; the survey was designed to map the location and thickness of the shale unit. The survey area also overlaps the Upper Mississippi Valley mineral district in southwestern Wisconsin that is known to host zinc and lead mineralization in other Ordovician strata.

Airborne hyperspectral remote sensing surveys.—In 2024, more than $5 million was invested in new hyperspectral remote sensing data in the Western United States. The collection of high-altitude regional hyperspectral data in 2022 was conducted through a partnership with the National Aeronautics and Space Administration using the Airborne Visible/InfraRed Imaging Spectrometer (AVIRIS-Classic). Secondary thermal infrared (TIR) sensors such as MASTER and HyTES were also used as available. New hyperspectral data have been collected over parts of Arizona, California, Nevada, and New Mexico, and the reflectance data are being calibrated by concurrent ground studies conducted by USGS scientists. In 2024, new data coverage totaled approximately 368,000 square kilometers (142,000 square miles) of the Western and Southwestern United States. When combined with data collected through Earth MRI in 2023 and with legacy data funded by the USGS Mineral Resources Program in 2018, current coverage of these hyperspectral data exceeds 802,000 square kilometers (310,000 square miles), which is presently the largest terrestrial area of contiguous hyperspectral coverage at 15-meter spatial resolution.

In 2024, a district-scale hyperspectral survey was conducted over selected areas of eastern Arizona and western New Mexico. The selected areas included active and legacy mine sites and surrounding bedrock areas that may host critical mineral resources. Detailed descriptions of these and other Earth MRI-funded projects can be accessed using the Earth MRI Acquisitions Viewer (https://ngmdb.usgs.gov/emri/).

U.S. Production and Consumption of Critical Minerals in 2024

In 2024, the value of domestic primary mine production of critical minerals was $3.3 billion, a 24% decrease from $4.1 billion in 2023. Reduced prices for these mineral commodities contributed the most to the reduced value and delayed new production or restarting production of some critical minerals. At least 12 individual mineral commodities and the rare-earths group of minerals (without specification of the specific lanthanides) had primary production in the United States. Zinc contributed the most to the total value of critical-mineral production (70%), followed by palladium and rare-earth elements (8% each).

The United States was 100% net import reliant for 12 of the 50 individually listed critical minerals and was more than 50% net import reliant for an additional 28 critical mineral commodities (including 14 lanthanides, which are listed under rare earths) (fig. 2, tables 4, 5). The United States had secondary production for 13 critical minerals, which resulted in net import reliance being less than 100%. The total value of domestically recycled critical mineral commodities in 2024 was $9.7 billion, 20% of the $48 billion of domestically recycled old scrap. Recycling provided the only source of domestic supply for antimony, bismuth, chromium, germanium, magnesium metal, tin, tungsten, and vanadium (table 5).

China was the leading producing country for 30 of 44 critical minerals (including 14 lanthanides, which are listed under rare earths) for which information was available to make reliable estimates. The other leading producing countries of critical minerals were South Africa with three critical minerals and Australia and Congo (Kinshasa) with two critical minerals each (table 5). Production of several critical minerals was highly concentrated (50% or more) in a single country: 5 critical minerals had 80% or more of global production dominated by one country, 6 critical minerals had 70% to less than 80% of global production dominated by one country, 17 critical minerals (including 14 lanthanides, which are listed under rare earths) had 60% to less than 70% of global production dominated by one country, and 2 critical minerals had 50% to less than 60% of global production dominated by one country (table 5).

Figure 9 shows the trends in net import reliance for critical minerals over the past 20 years. For most critical minerals, the United States has been heavily reliant on foreign sources for its consumption requirements; exceptions in 2024 include beryllium, tellurium, and zirconium.

Figure 10 shows both the 1-year percent change in prices of critical mineral commodities between 2023 and 2024 and the 5-year compound annual growth rate (CAGR) in the prices for critical minerals from 2020 through 2024. In 2024, the 1-year percent change in the prices of antimony and germanium increased by more than 50% compared with their respective prices in 2023. These changes are attributed to export restrictions. Prices decreased by 66% for lithium and decreased by more than 20% for cobalt, dysprosium, magnesium metal, neodymium, nickel, palladium, rhodium, terbium, vanadium, and yttrium. The CAGR for many critical minerals has been positive over the past 5 years, but there is a trend of decreasing prices for some mineral commodities: cerium, cobalt, europium, gallium, graphite, lanthanum, palladium, rhodium, and vanadium.

In 2024, consumption for many mineral commodities decreased from that in 2023 (fig. 11). There were reduced imports for many mineral commodities, which was reflected in the reduction in consumption in 2024.

For the 5-year period from 2020 through 2024, consumption declined for many mineral commodities indicating substitution of the material or potentially less domestic production of downstream products that required the raw mineral commodities. The largest decreases (greater than 25%) in consumption, in descending order, were for thallium, asbestos, bauxite, bismuth, industrial diamond (stones), and strontium. The largest increases (greater than 25%) in consumption, in descending order, were for indium, vanadium, natural graphite, industrial sand and gravel, platinum, niobium, and feldspar (fig. 12).

In 2024, the value of domestically recycled old scrap was $48 billion and the total value of net exports of old scrap was $18 billion (fig. 1). The total value of old scrap domestically recycled, imported, and exported was $82 billion. The mineral commodities with the highest value of domestically recycled old scrap as a percentage of the commodity’s total old scrap value (domestically recycled, imported, and exported) were antimony, lead, and tin. Antimony and lead were primarily consumed and recycled in lead-acid batteries. The mineral commodities with the highest value of exports in proportion to total old scrap value, in descending order, were copper, silver, aluminum, chromium, and gold. In 2024, domestic secondary processing capacity of copper increased because one new secondary smelter became operational. Another secondary copper plant was under construction and there were three secondary aluminum facilities under construction in 2024. The mineral commodities with the highest value of imports in proportion to total old scrap value, in descending order, were titanium, magnesium metal, cobalt, and platinum-group metals (fig. 13).

Figure 14 shows the relation between primary metals and byproduct or companion metals. As discussed in USGS Open-File Report 2021–1045, “Methodology and Technical Input for the 2021 Review and Revision of the U.S. Critical Minerals List,” the degree to which a metal is obtained largely or entirely as a byproduct of one or more host metals from ores may complicate the supply of these mineral commodities.

Table 5.—Estimated Salient Critical Minerals Statistics in 2024[1]

(Metric tons, mine production, unless otherwise specified)

Critical mineral	United States					World			
	Primary production	Secondary production	Apparent consumption	Net import reliance as a percentage of apparent consumption	Primary import source (2020–23)	Leading producing country	Production in leading country	Percentage of world total	World production total
Aluminum (metallurgical grade bauxite)	—	—	[2]1,800,000	>75	Jamaica	Guinea	130,000,000	29	[3]450,000,000
Antimony	—	3,500	24,000	85	China[4]	China	60,000	60	100,000
Arsenic	—	NA	[5]9,100	100	China[4]	Peru	[6]27,000	47	[6]58,000
Barite	W	—	W	>75	India	India	2,600,000	32	[3]8,200,000
Beryllium	180	NA	170	E	Kazakhstan	United States	180	50	360
Bismuth[7]	—	80	760	89	China[4]	China	13,000	81	16,000
Chromium	—	100,000	440,000	77	South Africa	South Africa	21,000,000	45	47,000,000
Cobalt	300	2,000	8,500	76	Norway	Congo (Kinshasa)	220,000	76	290,000
Fluorspar	NA	—	430,000	100	Mexico	China	5,900,000	62	9,500,000
Gallium	—	—	[2]19	100	Japan	China	750	99	760
Germanium[7]	—	NA	NA	>50	Belgium	China	NA	NA	NA
Graphite (natural)	—	—	52,000	100	China[4]	China	1,270,000	79	1,600,000
Indium[7]	—	—	[5]250	100	Republic of Korea	China	760	70	1,080
Lithium	W	NA	W	>50	Chile	Australia	88,000	37	[3]240,000
Magnesium[7]	—	110,000	[2]50,000	>75	Israel	China	950,000	95	[3]1,000,000
Manganese	—	—	680,000	100	Gabon	South Africa	7,400,000	37	20,000,000
Nickel	8,000	92,000	[8]180,000	48	Canada	Indonesia	2,200,000	59	3,700,000
Niobium	—	NA	8,400	100	Brazil	Brazil	100,000	91	110,000
Palladium	8	45	83	36	Russia	Russia	75	39	190
Platinum	2	8.5	71	85	South Africa	South Africa	120	71	170
Rare earths (compounds and metals)[9]	1,300	NA	6,600	80	China[4]	China	[10]270,000	69	[10]390,000
Scandium	—	—	NA	100	Japan	China	NA	NA	NA
Tantalum	—	NA	770	100	China[4]	Congo (Kinshasa)	880	42	2,100
Tellurium[7]	W	—	W	<25	Canada	China	750	77	[3]980
Tin	—	17,900	37,000	73	Peru	China	69,000	23	300,000
Titanium (metal)[7]	W	W	[3]40,000	>95	Japan	China	220,000	69	[3]320,000
Tungsten	—	W	W	>50	China[4]	China	67,000	83	81,000
Vanadium	—	8,200	14,000	40	Canada	China	70,000	70	100,000
Yttrium	NA	—	500	100	China[4]	China	NA	NA	NA
Zinc[7]	[11]220,000	([11])	820,000	73	Canada	China	4,000,000	33	12,000,000
Zirconium (ores and concentrates)	<100,000	NA	<100,000	<25	South Africa	Australia	500,000	33	1,500,000

E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.

[1]Critical minerals as published in the Federal Register on February 24, 2022 (87 FR 10381). Not all critical minerals are listed here. Cesium, hafnium, iridium, rhodium, rubidium, and ruthenium are not shown because available information was inadequate to make estimates of U.S. or world production.

[2]Reported consumption.

[3]Excludes U.S. production.

[4]Includes Hong Kong.

[5]Estimated consumption.

[6]Arsenic trioxide.

[7]Refinery production.

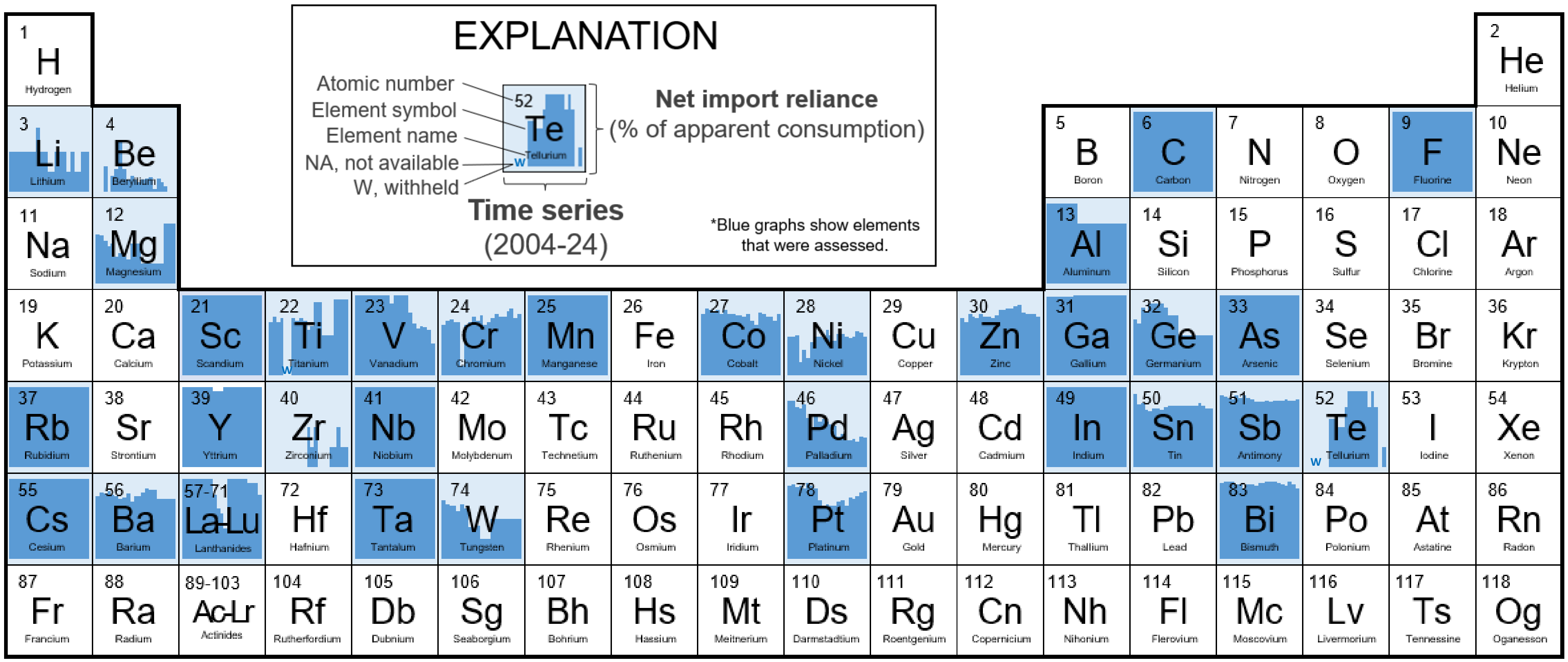
[8]Nickel in primary metal and secondary scrap.

[9]Data include lanthanides cerium, dysprosium, erbium, europium, gadolinium, holmium, lanthanum, lutetium, neodymium, praseodymium, samarium, terbium, thulium, and ytterbium.

[10]Mine production of rare-earth concentrates.

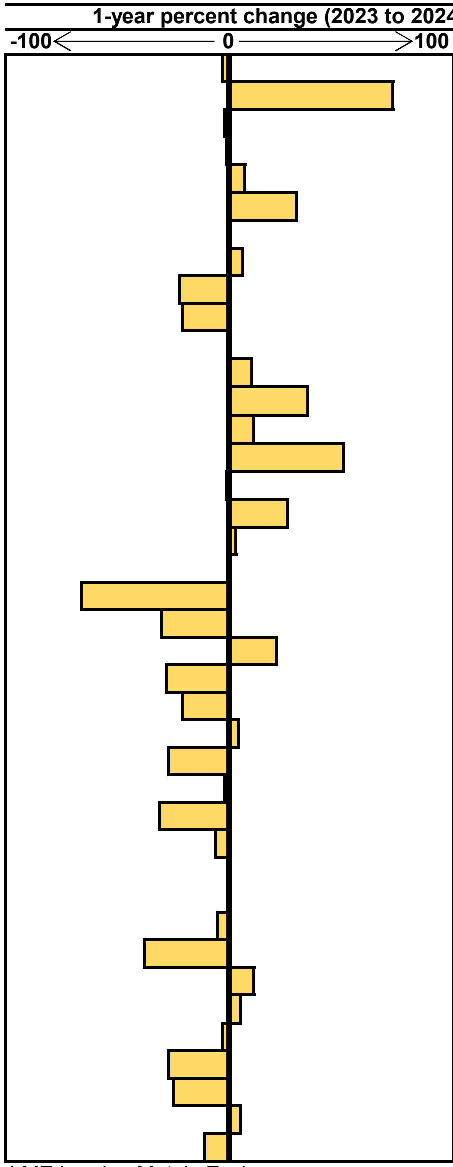
[11]Primary production includes both primary and secondary metal production.

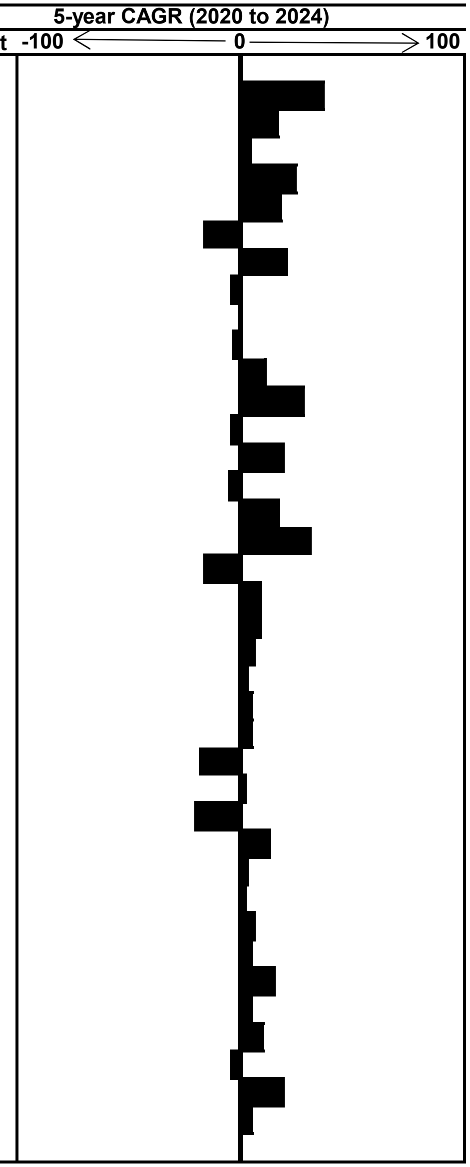
Figure 9.—20-Year Trend of U.S. Net Import Reliance for Critical Minerals



For elements of the periodic table associated with mineral commodities identified as critical in 2024 (87 FR 10381), the figure displays the U.S. net import reliance (NIR) as a percent of apparent consumption from 2004 through 2024. Barite is listed under barium (Ba). Bauxite is listed under aluminum (Al). Fluorspar is listed under fluorine (F). Graphite (natural) is listed under carbon (C). Rare earths are listed under lanthanides (La–Lu). Net import reliance data were not available for hafnium, iridium, and rhodium for 2004 through 2024; data were withheld for tellurium prior to 2010 and for titanium for 2008 and 2009. For some years, the NIR for antimony, barite, bauxite, germanium, lithium, magnesium, rare earths, tellurium, titanium, tungsten, yttrium, and zirconium are rounded to avoid disclosing company proprietary data.

Figure 10.—Estimated 1-Year Percent Change and 5-Year Compound Annual Growth Rate (CAGR) in Prices of Critical Minerals[1]





1-year percent change (2023 to 2024) Percent	Critical mineral commodity (price source)[2]	5-year CAGR (2020 to 2024) Percent
-3	Aluminum, bauxite	0
73	Antimony, metal	37
-2	Arsenic, metal	17
-1	Barite	5
7	Beryllium[3]	25
30	Bismuth	18
0	Cerium, oxide 99.5% minimum	-16
6	Chromium, chromite ore	21
-22	Cobalt (LME)	-4
-21	Dysprosium, oxide 99.5% minimum	0
0	Europium, oxide 99.99% minimum	-3
10	Fluorspar, acid grade[3]	11
35	Fluorspar, metallurgical grade[3]	28
11	Gallium, high purity refined[3]	-4
51	Germanium, metal	19
-1	Graphite, natural, flake[3]	-5
26	Indium (Rotterdam)	17
3	Iridium	31
0	Lanthanum, oxide 99.5% minimum	-16
-66	Lithium, battery grade lithium carbonate	9
-30	Magnesium, metal (U.S. spot Western)	9
21	Manganese	6
-28	Neodymium, oxide 99.5% minimum	3
-21	Nickel	5
4	Niobium, ferroniobium[3]	5
-27	Palladium	-18
-2	Platinum	2
-31	Rhodium	-20
-6	Ruthenium	13
0	Scandium, ingot	3
0	Tantalum	2
-5	Tellurium (U.S.)	6
-38	Terbium, oxide 99.99% minimum	5
11	Tin (New York dealer)	15
5	Titanium, sponge[3]	5
-3	Tungsten, concentrate	10
-27	Vanadium, vanadium pentoxide	-4
-25	Yttrium, oxide	19
5	Zinc (LME)	5
-11	Zirconium, sponge[3]	0

LME London Metals Exchange.

[1]Critical minerals as published in the Federal Register on February 24, 2022 (87 FR 10381). Not all critical minerals are listed here. Cesium, erbium, gadolinium, hafnium, holmium, lutetium, praseodymium, rubidium, samarium, thulium, and ytterbium are not shown because available information regarding prices was inadequate.

[2]Price source is only included for those commodities that have multiple price sources in their Salient table. For those commodities with a single price source, please refer to that commodity chapter's Salient Statistics table.

[3]Average annual unit value of imports.

Figure 11.—Change in U.S. Consumption of Nonfuel Mineral Commodities From 2023 to 2024

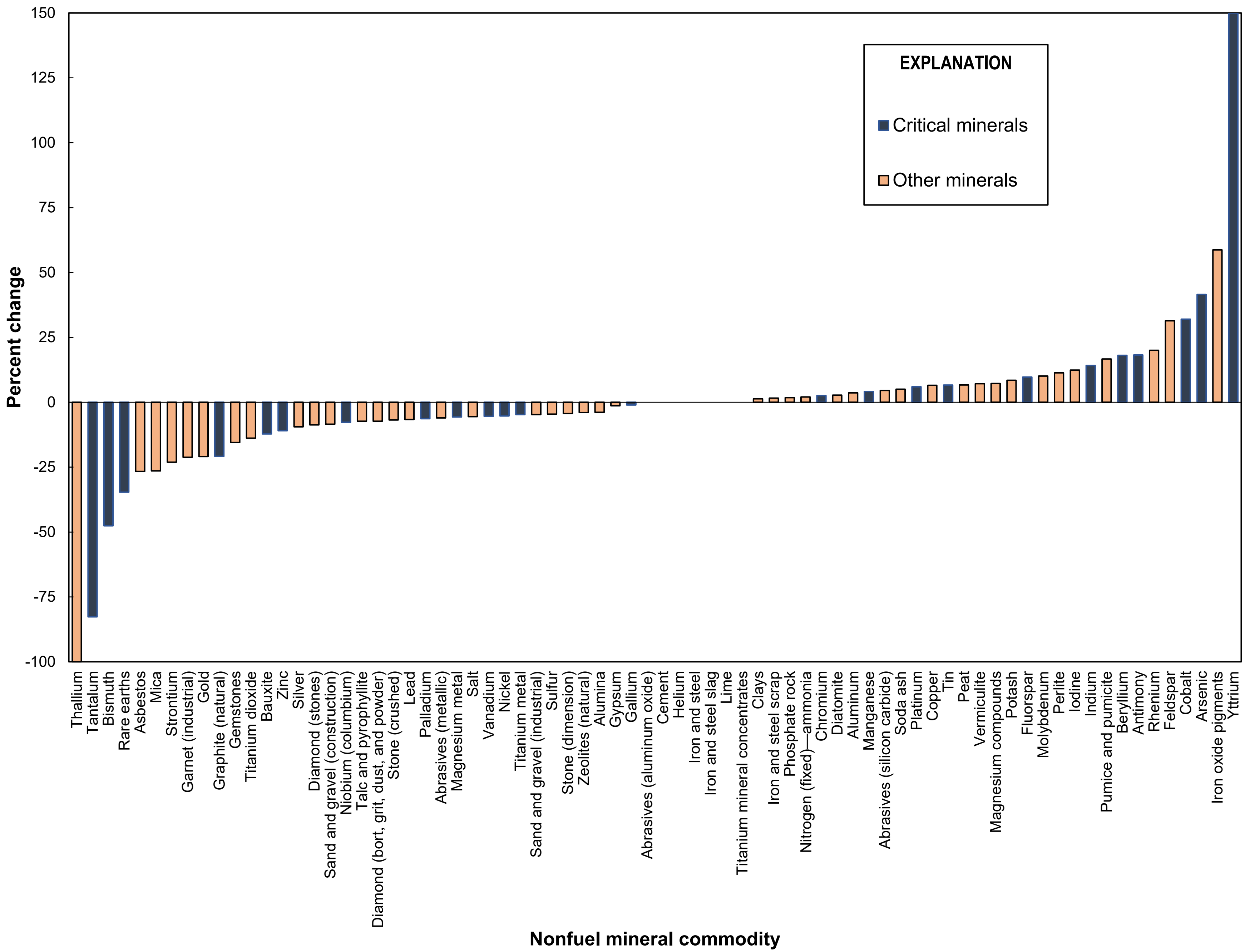


Figure 12.—Change in U.S. Consumption of Nonfuel Mineral Commodities From 2020 to 2024

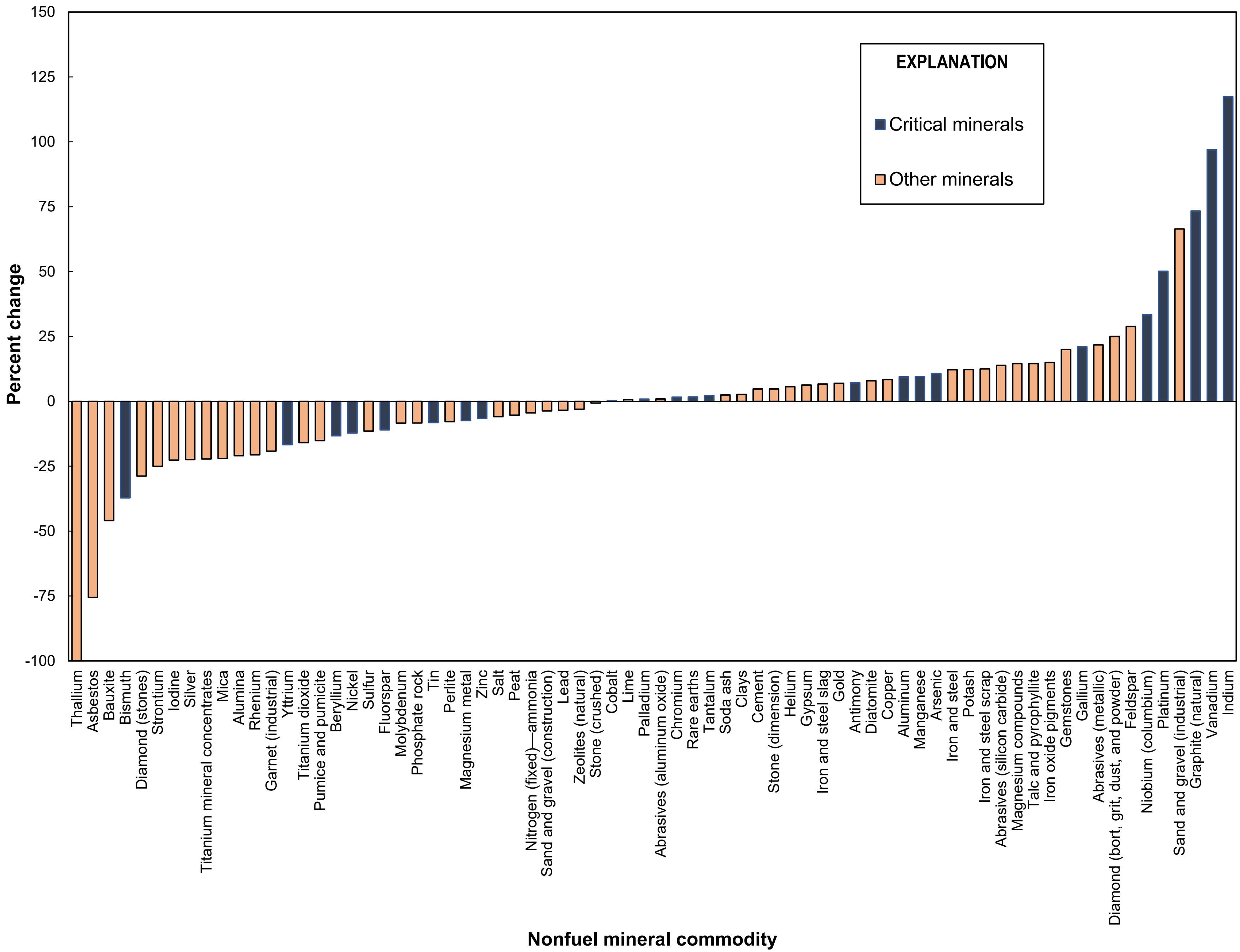
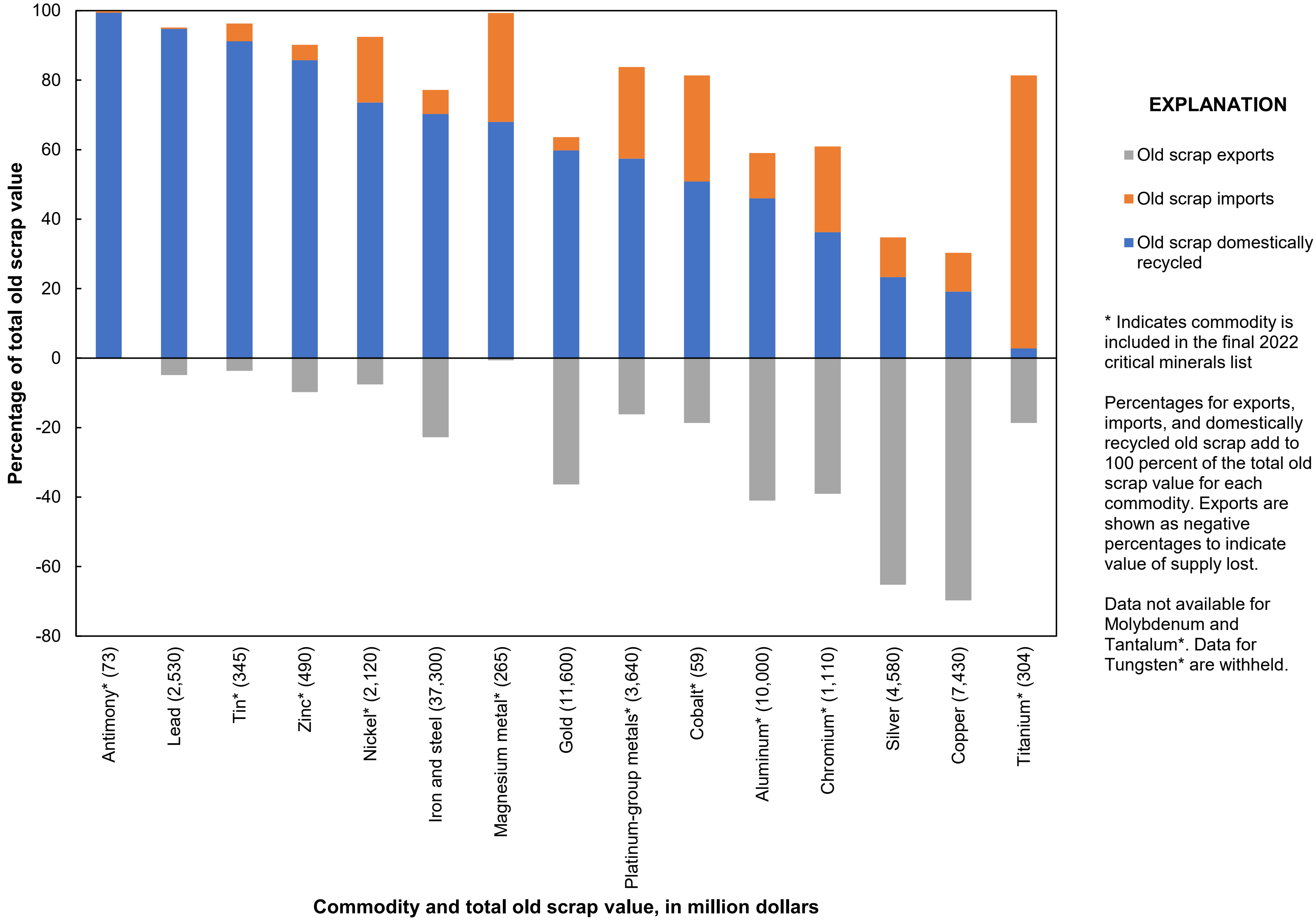


Figure 13.—Value of Old Scrap Domestically Recycled, Imported, and Exported in 2024, as a Percentage of Total Old Scrap Value

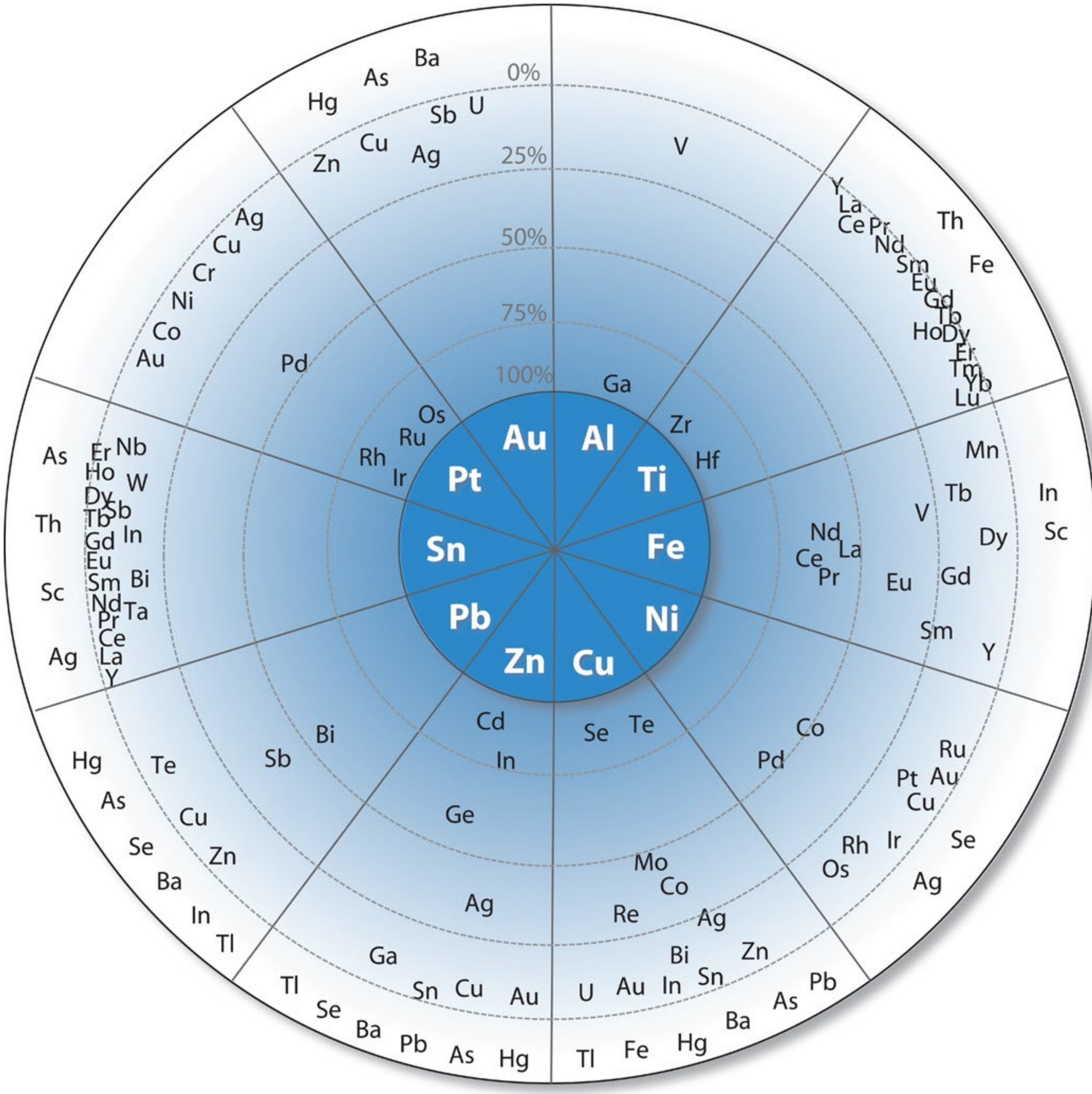


* Indicates commodity is included in the final 2022 critical minerals list

Percentages for exports, imports, and domestically recycled old scrap add to 100 percent of the total old scrap value for each commodity. Exports are shown as negative percentages to indicate value of supply lost.

Data not available for Molybdenum and Tantalum*. Data for Tungsten* are withheld.

Figure 14.—Relation Between Byproduct Elements and Host Metals



The principal host metals form the inner circle. Byproduct elements are in the outer circle at distances proportional to the percentage of their primary production (from 100% to 0%) that originates with the host metal indicated. The companion elements in the white region of the outer circle are elements for which the percentage of their production that originates with the host metal indicated has not been determined. Al, aluminum; Ag, silver; As, arsenic; Au, gold; Ba, barium; Bi, bismuth; Cd, cadmium; Ce, cerium; Co, cobalt; Cr, chromium; Cu, copper; Dy, dysprosium; Er, erbium; Eu, europium; Fe, iron; Ga, gallium; Gd, gadolinium; Ge, germanium; Hf, hafnium; Hg, mercury; Ho, holmium; In, indium; Ir, iridium; La, lanthanum; Lu, lutetium; Mn, manganese; Mo, molybdenum; Nd, neodymium; Ni, nickel; Os, osmium; Pb, lead; Pd, palladium; Pt, platinum; Pr, praseodymium; Re, rhenium; Rh, rhodium; Ru, ruthenium; Sb, antimony; Sc, scandium; Se, selenium; Sm, samarium; Sn, tin; Ta, tantalum; Tb, terbium; Te, tellurium; Th, thorium; Ti, titanium; Tl, thallium; U, uranium; V, vanadium; W, tungsten; Y, yttrium; Yb, ytterbium; Zn, zinc; Zr, zirconium. Source: Nassar, N.T., Graedel, T.E., and Harper, E.M., 2015, By-product metals are technologically essential but have problematic supply: ScienceAdvances, v. 1, no. 3, article E1400180. (Accessed December 19, 2023, at https://doi.org/10.1126/sciadv.1400180.)

ABRASIVES (MANUFACTURED)

(Fused aluminum oxide, silicon carbide, and metallic abrasives)
(Data in metric tons unless otherwise specified)

Domestic Production and Use: In 2024, fused aluminum oxide was produced by two companies at three plants in the United States and Canada. Production of crude fused aluminum oxide had an estimated value of $3.9 million. Silicon carbide was produced by two companies at two plants in the United States. Production of crude silicon carbide had an estimated value of about $25 million. Metallic abrasives were produced by 11 companies in eight States. Production of metallic abrasives had an estimated value of about $160 million, and metallic abrasive shipments were valued at $310 million. Bonded and coated abrasive products accounted for most abrasive uses of fused aluminum oxide and silicon carbide. Metallic abrasives are used primarily for steel shot and grit and cut wire shot, which are used for sandblasting, peening, and stonecutting applications.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Fused aluminum oxide, crude[1, 2]	10,000	10,000	20,000	25,000	25,000
Silicon carbide[2]	35,000	35,000	40,000	45,000	45,000
Metallic abrasives	176,000	176,000	180,000	198,000	200,000
Shipments, metallic abrasives	194,000	193,000	199,000	227,000	230,000
Imports for consumption:					
Fused aluminum oxide	121,000	159,000	225,000	120,000	120,000
Silicon carbide	88,400	125,000	165,000	114,000	110,000
Metallic abrasives	25,800	26,400	20,100	17,800	17,000
Exports:					
Fused aluminum oxide	11,400	13,500	14,400	9,540	9,400
Silicon carbide	8,310	12,000	12,000	10,100	11,000
Metallic abrasives	18,000	20,100	23,900	24,100	20,000
Consumption, apparent:					
Fused aluminum oxide[3]	109,000	146,000	210,000	110,000	110,000
Silicon carbide[4]	115,000	148,000	193,000	149,000	140,000
Metallic abrasives[5]	202,000	199,000	195,000	220,000	230,000
Price, average unit value of imports, dollars per metric ton:					
Fused aluminum oxide, crude	666	674	797	655	620
Fused aluminum oxide, ground and refined	1,180	1,290	1,560	1,380	1,500
Silicon carbide, crude	628	587	1,080	905	770
Metallic abrasives	1,130	1,510	2,130	1,850	2,000
Net import reliance[6] as a percentage of apparent consumption:					
Fused aluminum oxide	>95	>95	>95	>95	>95
Silicon carbide	70	76	79	70	69
Metallic abrasives	4	3	E	E	E

Recycling: Up to 30% of fused aluminum oxide may be recycled, and about 5% of silicon carbide is recycled.

Import Sources (2020–23): Fused aluminum oxide, crude: China, 91%; and other, 9%. Fused aluminum oxide, ground and refined: Canada, 28%; Brazil, 19%; China, 15%; Austria, 14%; and other, 24%. Total fused aluminum oxide: China, 64%; Canada, 11%; Brazil, 7%; Austria, 5%; and other, 13%. Silicon carbide, crude: China, 94%; and other, 6%. Silicon carbide, ground and refined: China, 58%; Brazil, 16%; Canada, 11%; Norway, 8%; and other, 7%. Total silicon carbide: China, 85%; Brazil, 4%; Canada, 3%; and other, 8%. Metallic abrasives: Canada, 47%; Turkey, 12%; Thailand, 9%; Japan, 7%; and other, 25%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Artificial corundum, crude	2818.10.1000	Free.
White, pink, ruby artificial corundum, greater than 97.5% aluminum oxide, grain	2818.10.2010	1.3% ad valorem.
Artificial corundum, not elsewhere specified or included, fused aluminum oxide, grain	2818.10.2090	1.3% ad valorem.
Silicon carbide, crude	2849.20.1000	Free.
Silicon carbide, grain	2849.20.2000	0.5% ad valorem.
Iron, pig iron, or steel granules	7205.10.0000	Free.

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ABRASIVES (MANUFACTURED)

Depletion Allowance: None.

Government Stockpile: None.

Events, Trends, and Issues: In 2024, China was the world's leading manufacturer of abrasive fused aluminum oxide and abrasive silicon carbide. Imports from China, where production costs were lower, continued to challenge abrasives manufacturers in the United States and Canada. China accounted for 94% of United States imports of crude fused aluminum oxide, 14% of ground and refined fused aluminum oxide imports, 98% of crude silicon carbide imports, and 67% of ground and refined silicon carbide imports. Foreign competition was expected to persist and continue to limit production in North America. The import quantities of abrasive silicon carbide (crude and ground and refined) in 2024 were 5% less and 13% more, respectively, than those in 2023.

The United States was a net exporter of metallic abrasives in 2024, 2023, and 2022 compared with being a net importer in 2021 and 2020. The import quantity of metallic abrasives in 2024 was 6% less than that in 2023. Canada was the leading supplier of metallic abrasive imports.

The consumption of abrasives in the United States is influenced by activity in the manufacturing sectors that use them, particularly the aerospace, automotive, furniture, housing, and steel industries. The U.S. abrasive markets also are influenced by technological trends.

World Production Capacity:

	Fused aluminum oxide[e]		Silicon carbide[e]	
	2023	2024	2023	2024
United States	—	—	40,000	40,000
United States and Canada	60,000	60,000	—	—
Australia	50,000	50,000	—	—
Austria	90,000	90,000	—	—
Brazil	50,000	50,000	40,000	40,000
China	800,000	800,000	450,000	450,000
France	40,000	40,000	20,000	20,000
Germany	80,000	80,000	35,000	35,000
India	40,000	40,000	5,000	5,000
Japan	15,000	15,000	60,000	60,000
Mexico	—	—	45,000	45,000
Norway	—	—	80,000	80,000
Venezuela	—	—	30,000	30,000
Other countries	80,000	80,000	200,000	200,000
World total (rounded)	1,310,000	1,310,000	1,010,000	1,010,000

World Resources:[7] Although domestic resources of raw materials for fused aluminum oxide production are limited, adequate resources are available in the Western Hemisphere. Domestic resources are more than adequate for silicon carbide production.

Substitutes: Natural and manufactured abrasives, such as garnet, emery, metallic abrasives, or staurolite, can be substituted for fused aluminum oxide and silicon carbide in various applications.

[e]Estimated. E Net exporter. — Zero.
[1]Production data for fused aluminum oxide are combined data from the United States and Canada to avoid disclosing company proprietary data.
[2]Rounded to the nearest 5,000 tons to avoid disclosing company proprietary data.
[3]Defined as imports – exports because production includes data from Canada; actual consumption is higher than that shown.
[4]Defined as production + imports – exports.
[5]Defined as shipments + imports – exports.
[6]Defined as imports – exports.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.

ALUMINUM[1]

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: In 2024, two companies operated four primary aluminum smelters in four States. Two of these smelters operated at full capacity throughout the year, whereas two smelters operated at reduced capacity. One smelter located in Hawesville, KY, has been temporarily shut down since 2022, and another smelter in New Madrid, MO, was temporarily shut down in January. Domestic smelter capacity was 1.36 million tons per year in 2024, unchanged from that in 2023. Estimated primary production decreased by 11% from that in 2023, whereas estimated secondary production from new and old scrap was 5% more than that in 2023. Based on published prices, the value of primary aluminum production was about $1.9 billion, 9% less than that in 2023. The estimated average annual U.S. market price increased by 3% from that in 2023. Transportation applications accounted for 36% of domestic consumption; the remainder was used in packaging, 23%; building, 14%; electrical, 9%; consumer durables and machinery, 8% each; and other, 2%.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Primary	1,010	889	861	750	670
Secondary (from old scrap)	1,420	1,520	1,480	1,560	1,600
Secondary (from new scrap)	1,630	1,780	1,920	1,870	2,000
Imports for consumption:					
Crude and semimanufactures	4,260	4,820	5,710	4,890	4,800
Scrap	542	679	685	677	660
Exports:					
Crude and semimanufactures	906	900	1,040	1,230	1,400
Scrap	1,840	2,100	2,000	2,060	1,600
Consumption, apparent[2]	3,930	4,020	4,890	4,150	4,300
Supply, apparent[3]	5,560	5,800	6,810	6,010	6,300
Price, ingot, average U.S. market (spot), cents per pound[4]	89.7	138.5	152.6	125.9	130
Stocks, yearend:					
Aluminum industry	1,490	1,870	2,050	1,820	1,600
London Metal Exchange (LME), U.S. warehouses[5]	235	69	9	5	10
Employment, number[6]	30,100	28,900	30,200	30,500	30,000
Net import reliance[7] as a percentage of apparent consumption	38	40	52	44	47

Recycling: In 2024, aluminum recovered from purchased scrap in the United States was about 3.6 million tons, of which about 56% came from new scrap (manufacturing) and 44% from old scrap (discarded aluminum products). Aluminum recovered from old scrap was equivalent to about 37% of apparent consumption.

Import Sources (2020–23): Canada, 56%; United Arab Emirates, 8%; Bahrain, 4%; China,[8] 3%; and other, 29%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Aluminum, not alloyed:		
Unwrought (in coils)	7601.10.3000	2.6% ad valorem.
Unwrought (greater than 99.8% aluminum)	7601.10.6030	Free.
Aluminum alloys, unwrought (billet)	7601.20.9045	Free.
Aluminum scrap:		
Used beverage container scrap	7602.00.0035	Free.
Industrial process scrap	7602.00.0095	Free.
Other	7602.00.0097	Free.

Depletion Allowance: Not applicable.[1]

Government Stockpile:[9]

	FY 2024		FY 2025	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Aluminum, high-purity and alloys	18.5	—	3.2	—

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ALUMINUM

Events, Trends, and Issues: In January 2024, a 263,000-ton-per-year primary aluminum smelter in New Madrid, MO, shut down its full production with no scheduled restart. In June, a Republic of Korea-based auto parts manufacturer opened a $128 million production and casting facility in Tuskegee, AL. The facility produced aluminum components for an automobile manufacturing plant in Montgomery, AL. In September, construction began on a $40 million aluminum recycling facility in Russellville, KY, which will process dross and scrap from a nearby aluminum casting plant. Also in September, a United Arab Emirates-based aluminum producer announced the acquisition of a 110,000-ton-per-year United States-based secondary aluminum producer located in Rosemont, MN.

In March, the U.S. Department of Energy announced grants to four aluminum operations, including $500 million to build a new aluminum smelter within the Ohio River and Mississippi River Basins; $75 million to build a low-carbon aluminum casting plant in Ravenswood, WV; $67.3 million to build a low-waste recycling facility in Wabash, IN; and $22.3 million to upgrade casting and rolling equipment at a casting and rolling mill in Fort Lupton, CO. In July, the U.S. Department of Defense awarded $23 million to increase aluminum casting capacity by as much as 136,000 tons per year at an aluminum rolling facility in Muscle Shoals, AL.

In April, the United States coordinated with the United Kingdom to ban imports of aluminum from Russia into both countries and to restrict the sale of these metals on global metal exchanges and in over-the-counter derivative trading. In July, the United States imposed 10% duties on imports of aluminum products and derivative aluminum products from Mexico that contain primary aluminum for which the primary or secondary country of smelt or the most recent country of cast was Belarus, China, Iran, or Russia. In September, the United States increased tariffs on aluminum products imported from China, from 0%–7.5% to 25%.

World Smelter Production and Capacity: Capacity data for China, India, and other countries were revised based on company and Government reports.

	Smelter production		Yearend capacity	
	2023	2024[e]	2023	2024[e]
United States	750	670	1,360	1,360
Australia	1,560	1,500	1,730	1,730
Bahrain	1,620	1,600	1,600	1,600
Brazil	1,020	1,100	1,280	1,280
Canada	[e]3,200	3,300	3,270	3,270
China	41,600	43,000	44,400	44,700
Iceland	[e]770	780	880	880
India	[e]4,100	4,200	4,100	4,200
Malaysia	[e]940	870	1,080	1,080
Norway	[e]1,300	1,300	1,460	1,460
Russia	[e]3,700	3,800	4,080	4,080
United Arab Emirates	2,660	2,700	2,790	2,790
Other countries	6,780	6,800	10,300	10,000
World total (rounded)	70,000	72,000	78,300	78,400

World Resources:[10] Global resources of bauxite are estimated to be between 55 billion and 75 billion tons and are sufficient to meet world demand for aluminum metal well into the future.

Substitutes: Composites can substitute for aluminum in aircraft fuselages and wings. Glass, paper, plastics, and steel can substitute for aluminum in packaging. Composites, magnesium, steel, and titanium can substitute for aluminum in ground transportation uses. Composites, steel, vinyl, and wood can substitute for aluminum in construction. Copper can replace aluminum in electrical and heat-exchange applications.

[e]Estimated. — Zero.
[1]See also the Bauxite and Alumina chapter.
[2]Defined as primary production + secondary production from old scrap + imports – exports ± adjustments for stock changes; excludes imported scrap.
[3]Defined as primary production + secondary production + imports – exports ± adjustments for stock changes; excludes imported scrap.
[4]Source: S&P Global Platts Metals Week.
[5]Includes off-warrant stocks of primary and alloyed aluminum.
[6]Alumina and aluminum production workers (North American Industry Classification System—3313). Source: U.S. Department of Labor, Bureau of Labor Statistics.
[7]Defined as imports – exports ± adjustments for industry stock changes; excludes imported scrap.
[8]Includes Hong Kong.
[9]See Appendix B for definitions.
[10]See Appendix C for resource and reserve definitions and information concerning data sources.

ANTIMONY

(Data in metric tons, antimony content, unless otherwise specified)

Domestic Production and Use: In 2024, no marketable antimony was mined in the United States. Primary antimony metal and oxide were produced by one company in Montana using imported feedstock; data were not available. Secondary antimony production came from antimonial lead recovered from spent lead-acid batteries and was intended for the lead-acid battery industry. The estimated value of secondary antimony produced in 2024 was about $73 million. Recycling supplied about 15% of estimated domestic apparent consumption, and the remainder came from imports. In the United States, the leading uses of antimony were metal products, including antimonial lead and ammunition, 40%; flame retardants, 39%; and nonmetal products, including ceramics and glass and rubber products, 21%.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Mine (recoverable antimony)	—	—	—	—	—
Smelter:					
Primary	254	19	W	W	W
Secondary	3,520	4,050	4,100	3,490	3,500
Imports for consumption:					
Ore and concentrates	105	31	29	6	310
Oxide	15,000	19,100	16,900	14,000	20,000
Unwrought, powder	5,200	6,970	6,510	6,060	4,100
Antimony articles[1]	318	514	1,790	1,620	330
Waste and scrap[1]	6	13	71	3	17
Exports:					
Ore and concentrates[1]	10	9	53	24	—
Oxide	1,230	1,530	2,420	1,740	2,200
Unwrought, powder	269	824	1,230	1,510	1,500
Antimony articles[1]	97	97	585	433	79
Waste and scrap[1]	11	136	26	2	53
Consumption, apparent[2]	22,400	27,800	23,900	20,300	24,000
Price, metal, average, dollars per pound[3]	2.67	5.31	6.18	5.49	9.50
Net import reliance[4] as a percentage of apparent consumption	83	85	83	83	85

Recycling: The bulk of secondary antimony is recovered at secondary lead smelters as antimonial lead, most of which was generated by, and then consumed by, the lead-acid battery industry.

Import Sources (2020–2023): Ore and concentrates: Italy, 44%; China, 23%; Belgium, 16%; India, 10%; and other, 7%. Oxide: China,[5] 76%; Belgium, 11%; Bolivia, 6%; and other, 7%. Unwrought metal and powder: India, 25%; China,[5] 24%; Thailand, 13%; Vietnam, 12%; and other, 26%. Total metal and oxide: China,[5] 63%; Belgium, 8%, India, 6%; Bolivia, 5%; and other, 18%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Ore and concentrates	2617.10.0000	Free.
Antimony oxide	2825.80.0000	Free.
Unwrought antimony; powders	8110.10.0000	Free.
Waste and scrap	8110.20.0000	Free.
Antimony articles	8110.90.0000	Free.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile:[6]

	FY 2024		FY 2025	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Antimony	1,100	—	700	—

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ANTIMONY

Events, Trends, and Issues: In August 2024, China's Government announced that companies would need to apply for export licenses to export antimony ore, metals, oxides, hydrides, indium antimonides, organo-antimony compounds, and gold-antimony separation technology. After that announcement, the antimony metal price nearly doubled, from $8.91 per pound in July to $17.50 per pound in November, according to Argus Media Group. In December 2024, China banned all exports of antimony to the United States.

In February, a mining company in Idaho was conditionally awarded additional funding from the U.S. Department of Defense to reestablish a domestic source of antimony, bringing its total Department of Defense funding to $59.4 million. According to the company, the project has total proven and probable mineral reserves of 14.2 million tons of 0.42% antimony ore.

World Mine Production and Reserves: Reserves for China and Vietnam were revised based on Government reports.

	Mine production		Reserves[7]
	2023	2024[e]	
United States	—	—	[8]60,000
Australia	1,860	2,000	[9]140,000
Bolivia	3,700	3,700	310,000
Burma	[e]4,500	4,500	140,000
Canada	—	—	78,000
China	[e]62,300	60,000	670,000
Guatemala	49	50	NA
Iran	[e]500	500	NA
Kazakhstan	[e]40	40	NA
Kyrgyzstan	20	20	260,000
Laos	[e]200	200	NA
Mexico	800	800	18,000
Pakistan	250	250	26,000
Russia	13,000	13,000	350,000
Tajikistan	17,000	17,000	50,000
Turkey	[e]1,600	1,600	99,000
Vietnam	300	300	54,000
World total (rounded)[10]	106,000	100,000	>2,000,000

World Resources:[7] U.S. resources of antimony are mainly in Alaska, Idaho, Montana, and Nevada. Principal identified world resources are in Australia, Bolivia, Burma, China, Mexico, Russia, South Africa, and Tajikistan. Additional antimony resources may occur in Mississippi Valley-type lead deposits in the Eastern United States.

Substitutes: Selected organic compounds and hydrated aluminum oxide are substitutes as flame retardants. Chromium, tin, titanium, zinc, and zirconium compounds substitute for antimony chemicals in enamels, paint, and pigments. Combinations of calcium, copper, selenium, sulfur, and tin are substitutes for alloys in lead-acid batteries.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Gross weight.
[2]Defined as secondary production from old scrap + imports of antimony in oxide and unwrought metal – exports of antimony in oxide and unwrought metal.
[3]Antimony minimum 99.65%, cost, insurance, and freight. Source: Argus Media Group, Argus Non-Ferrous Markets.
[4]Defined as imports of antimony in oxide and unwrought metal, powder – exports of antimony in oxide and unwrought metal, powder.
[5]Includes Hong Kong.
[6]See Appendix B for definitions.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]Company-reported probable reserves for the Stibnite Gold Project in Idaho.
[9]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 20,000 tons.
[10]In addition to the countries listed, antimony may have been produced in other countries, but available information was inadequate to make reliable estimates of output.

ARSENIC

(Data in metric tons, arsenic content,[1] unless otherwise specified)

Domestic Production and Use: Arsenic trioxide and primary arsenic metal have not been produced in the United States since 1985. The principal use for arsenic compounds was in herbicides and insecticides. Arsenic trioxide was predominantly used for the production of arsenic acid, which is a key ingredient in the production of chromated copper arsenate (CCA) preservatives. CCA preservatives are used for the pressure treating of lumber for primarily nonresidential applications such as light poles, marine applications, and retaining walls. Seven companies produced CCA-treated wood in the United States in 2024. High-purity (99.9999%) arsenic metal was used to produce gallium-arsenide (GaAs) semiconductors for solar cells, space research, and telecommunications; germanium-arsenide-selenide specialty optical materials; and indium-gallium-arsenide (InGaAs) for use in shortwave infrared technology. Arsenic metal was used as an antifriction additive for bearings, to harden lead shot and clip-on wheel weights, and to strengthen the grids in lead-acid storage batteries. The estimated value of arsenic compounds and metal imported domestically in 2024 was $11 million. Given that arsenic metal has not been produced domestically since 1985, it is likely that only a small portion of the material reported by the U.S. Census Bureau as arsenic exports was pure arsenic metal, and most of the material that was reported under this category reflects the gross weight of alloys, compounds, residues, scrap, and waste products containing arsenic. Therefore, the estimated consumption reported under U.S. salient statistics reflects only imports of arsenic products. Domestically, the leading uses of arsenic were as follows: herbicides and insecticides and wood preservatives, 84%; semiconductor, 5%; metallurgical, 3%; and other, 8%.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Imports for consumption:[2]					
Arsenic metal	522	835	934	612	530
Compounds	7,690	4,730	9,190	5,810	[3]8,600
Total	8,220	5,560	10,100	6,430	9,100
Exports, all forms of arsenic (gross weight)	29	31	82	40	[3]570
Consumption, estimated, all forms of arsenic[4]	8,220	5,560	10,100	6,430	9,100
Price, metal, annual average, U.S. warehouse,[5] dollars per pound	1.08	1.11	1.67	2.05	2
Net import reliance[6] as a percentage of estimated consumption, all forms of arsenic	100	100	100	100	100

Recycling: Arsenic metal was contained in new scrap recycled during GaAs semiconductor manufacturing. Arsenic-containing process water was internally recycled at wood treatment plants where CCA was used. Although scrap electronic circuit boards, relays, and switches may contain arsenic, no arsenic was known to have been recovered during the recycling process to recover other contained metals. No arsenic was recovered domestically from arsenic-containing residues and dusts generated at nonferrous smelters in the United States.

Import Sources (2020–23):[2] Arsenic acid: Malaysia, 99%; and other, 1%. Arsenic metal: China,[7] 96%; Japan, 3%; and other, 1%. Arsenic trioxide: China, 58%; Morocco, 34%; Belgium, 5%; and other, 3%. All forms of arsenic: China,[7] 52%; Morocco, 26%; Malaysia, 16%; Belgium, 4%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Arsenic metal	2804.80.0000	Free.
Arsenic acid	2811.19.1000	2.3% ad valorem.
Arsenic trioxide	2811.29.1000	Free.
Arsenic trichloride	2812.19.0010	3.7% ad valorem.
Arsenic sulfide	2813.90.1000	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Peru, China, and Morocco, in descending order of production, continued to be the leading global producers of arsenic trioxide, accounting for about 95% of estimated world production in 2024. China and the Republic of Korea accounted for 92% of United States imports of arsenic trioxide in 2024. China supplied 96% of United States arsenic metal imports through July 2024. Malaysia supplied all the arsenic acid that was imported through July 2024.

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ARSENIC

High-purity arsenic metal was used to produce GaAs, indium-arsenide, and InGaAs semiconductors that were used in aerospace devices, biomedical devices, military applications, mobile devices, optoelectronic devices, photovoltaic applications, satellites, and wireless communications. Total revenues from GaAs devices increased in 2024 because of an increase in the deployment of fifth-generation networks and consumer devices. A variety of GaAs wafer manufacturers ranging from large, multinational corporations to small, privately owned companies competed in this industry, but the top six producers accounted for more than 75% of the global market. See also the Gallium chapter.

World Production and Capacity:

	Production[e, 8] (arsenic trioxide, gross weight)		Refinery capacity (arsenic trioxide, gross weight)[9]
	2023	2024[e]	2024[e]
United States	—	—	—
Belgium	1,000	1,000	1,500
China	24,000	24,000	30,000
Japan[e]	40	40	60
Morocco	6,000	6,000	8,000
Peru	30,000	27,000	37,000
Russia[e]	500	200	4,000
World total (rounded)	61,500	58,000	81,000

World Resources:[10] Arsenic may be obtained from copper, gold, and lead smelter flue dust, as well as from roasting arsenopyrite, the most abundant ore mineral of arsenic. Arsenic has been recovered from orpiment and realgar in China, Peru, and the Philippines and from copper-gold ores in Chile, and arsenic is associated with gold occurrences in Canada. Orpiment and realgar from gold mines in Sichuan Province, China, were stockpiled for later recovery of arsenic. Arsenic also may be recovered from enargite, a copper mineral. Arsenic trioxide was produced at the hydrometallurgical complex of Guemassa, near Marrakech, Morocco, from cobalt-arsenide ore from the Bou Azzer Mine. World reserve data were unavailable but were estimated to be more than 20 times world production.

Substitutes: Substitutes for CCA in wood treatment include alkaline copper quaternary, ammoniacal copper quaternary, ammoniacal copper zinc arsenate, alkaline copper quaternary boron-based preservatives, copper azole, copper citrate, and copper naphthenate. Treated wood substitutes include concrete, plastic composite material, plasticized wood scrap, or steel. Silicon-based complementary metal-oxide semiconductor power amplifiers compete with GaAs power amplifiers in midtier third-generation cellular handsets. Many semiconductor manufacturers were moving away from GaAs- and silicon-based lateral diffused metal-oxide-semiconductor field-effect transistors to those using gallium nitride. Indium phosphide components can be substituted for GaAs-based infrared laser diodes in some specific-wavelength applications, and helium-neon lasers compete with GaAs in visible laser diode applications. Silicon is the principal competitor with GaAs in solar-cell applications. In many defense-related applications, GaAs-based integrated circuits are used because of their unique properties, and no effective substitutes exist for GaAs in these applications. In heterojunction bipolar transistors, GaAs is being replaced in some applications by silicon-germanium.

[e]Estimated. — Zero.

[1]Arsenic content of arsenic metal is 100%; arsenic content of arsenic compounds is 58.2% for arsenic acids, 60.7% for arsenic sulfides, 41.33% for arsenic trichloride, and 75.71% for arsenic trioxide.

[2]Arsenic content calculated from the reported gross weight of imports. See footnote 1 for content percentages of arsenic metal and compounds.

[3]In 2024, includes arsenic trichloride; imports were 450 tons, arsenic content, and exports were 380 tons, gross weight. There were no trade data for arsenic trichloride in previous years.

[4]Estimated to be the same as total imports.

[5]Minimum 99% arsenic. Source: Argus Media Group, Argus Non-Ferrous Markets.

[6]Defined as imports.

[7]Includes Hong Kong.

[8]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. Chile and Mexico were thought to be significant producers of commercial-grade arsenic trioxide but have reported no production in recent years.

[9]Yearend operation capacity.

[10]See Appendix C for resource and reserve definitions and information concerning data sources.

ASBESTOS

(Data in metric tons unless otherwise specified)

Domestic Production and Use: The last U.S. producer of asbestos ceased operations in 2002 as a result of the decline in domestic and international asbestos use associated with health and liability issues. Since then, the United States has been wholly dependent on imports to meet manufacturing needs. All of the unmanufactured asbestos fiber imported into and used within the United States has consisted of chrysotile since no later than 1999. In 2024, domestic consumption of chrysotile was estimated to be 110 tons; all consumption was from stockpiles, as no chrysotile was imported. The chloralkali industry, which uses chrysotile in nonreactive semipermeable diaphragms that prevent chlorine generated at the anode of an electrolytic cell from reacting with sodium hydroxide generated at the cathode, has accounted for 100% of U.S. asbestos fiber consumption since no later than 2015. In addition to unmanufactured asbestos fiber, an unknown quantity of asbestos is imported annually within manufactured products. According to the U.S. Environmental Protection Agency (EPA), the only imported items known to contain asbestos are aftermarket automotive brakes and linings and other vehicle friction products, brake blocks used in the oil industry, and sheet and other gaskets.[1]

Salient Statistics—United States:[2]	2020	2021	2022	2023	2024[e]
Imports for consumption[3]	305	41	224	—	—
Exports[4]	—	—	—	—	—
Consumption, estimated[5]	450	310	290	150	110
Price, average U.S. customs unit value of imports, dollars per ton	2,110	1,880	2,630	NA	NA
Net import reliance[6] as a percentage of estimated consumption	100	100	100	100	100

Recycling: None.

Import Sources (2020–23): Brazil, 91%; and Russia, 9%. The U.S. Census Bureau reported imports from China and Poland during this time period, but bill of lading information, data reported by the Government of China, and an asbestos ban in Poland suggest that these shipments were misclassified.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Crocidolite	2524.10.0000	Free.
Amosite	2524.90.0010	Free.
Chrysotile:		
Crudes	2524.90.0030	Free.
Milled fibers, group 3 grades	2524.90.0040	Free.
Milled fibers, group 4 and 5 grades	2524.90.0045	Free.
Other	2524.90.0055	Free.
Other, asbestos	2524.90.0060	Free.

Depletion Allowance: 22% (domestic), 10% (foreign).

Government Stockpile: None.

Events, Trends, and Issues: Consumption of unmanufactured asbestos fiber in the United States has decreased significantly during the past several decades, from a record high of 803,000 tons in 1973 to 500 tons or less in each year since 2018. This decline has taken place as a result of health and liability issues associated with asbestos use, leading to the displacement of asbestos from traditional domestic markets by substitutes, alternative materials, and new technology. The chloralkali industry is the only remaining U.S. consumer of asbestos in mineral form.

In March 2024, the EPA issued a final rule[1] that will prohibit the commercial use, distribution in commerce, import, manufacturing, and processing of chrysotile for all chrysotile-containing products that are still used in the United States: aftermarket automotive brakes and linings and other vehicle friction products, diaphragms used in the chloralkali industry, oilfield brake blocks, and sheet and other gaskets. Imports of chrysotile for use in the chloralkali industry were banned as of May 28, the effective date of the new regulation. The remaining eight chloralkali plants that use asbestos diaphragms will be required to transition to alternative materials; six of these facilities were expected to complete this conversion within 5 years, and the other two were projected to follow at a later date. The EPA ordered most other uses of asbestos to cease from 6 months to 2 years after the effective date of the rule. Asbestos-containing sheet gaskets used to produce titanium dioxide and in the processing of nuclear material will have a 5-year phaseout, and the U.S. Department of Energy's Savannah River site will be permitted to use asbestos-containing sheet gaskets in the disposal of nuclear materials through 2037. In 2019, the EPA banned all discontinued

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ASBESTOS

uses of asbestos from restarting without the EPA having an opportunity to evaluate each intended use and take any necessary regulatory action. Consequently, the March 2024 rule will effectively prohibit all uses of asbestos in the United States as of the compliance date for each specific application.

Globally, asbestos is used predominantly in cement pipe, roofing sheets, and other construction materials in Asia. Worldwide consumption of unmanufactured asbestos fiber ranged from an estimated 1.1 million to 1.4 million tons per year from 2015 through 2024, a significant decrease from approximately 2 million tons in 2000, and will likely remain steady for the foreseeable future.

World Mine Production and Reserves: In addition to the countries listed, Zimbabwe may have produced asbestos from old mine tailings; information on the status of these operations was unavailable.

	Mine production		Reserves[7]
	2023	2024[e]	
United States	—	—	Small
Brazil	[8]189,000	160,000	11,000,000
China	[e]200,000	200,000	18,000,000
Kazakhstan	255,000	210,000	Large
Russia	600,000	600,000	110,000,000
World total (rounded)	1,240,000	1,200,000	Large

World Resources:[7] Reliable evaluations of global asbestos resources have not been published recently, and available information was insufficient to make accurate estimates for many countries. However, world resources are large and more than adequate to meet anticipated demand in the foreseeable future. Resources in the United States are composed mostly of short-fiber asbestos for which use in asbestos-based products is more limited than long-fiber asbestos.

Substitutes: Numerous materials substitute for asbestos, including calcium silicate, carbon fiber, cellulose fiber, ceramic fiber, glass fiber, steel fiber, wollastonite, and several organic fibers, such as aramid, polyethylene, polypropylene, and polytetrafluoroethylene. Several nonfibrous minerals or rocks, such as perlite, serpentine, silica, and talc, are also considered to be possible asbestos substitutes for products in which the reinforcement properties of fibers are not required. Membrane cells and mercury cells are alternatives to asbestos diaphragms used in the chloralkali industry.

[e]Estimated. NA Not available. — Zero.
[1]Source: U.S. Environmental Protection Agency, 2024, Asbestos part 1—Chrysotile asbestos—Regulation of certain conditions of use under the Toxic Substances Control Act (TSCA): Federal Register, v. 89, no. 61, March 28, p. 21970–22010. (Accessed October 15, 2024, at https://www.govinfo.gov/content/pkg/FR-2024-03-28/pdf/2024-05972.pdf.)
[2]Includes unmanufactured asbestos fiber (chrysotile) only; excludes asbestos contained in manufactured products.
[3]Modified from reported U.S. Census Bureau data. Additional chrysotile imports from China were reported in 2021 (59 tons) and 2022 (99 tons), but bill of lading information and data reported by the Government of China suggest that these shipments were misclassified. The U.S. Census Bureau also reported imports of 2 tons from Poland in 2023 and 4 tons from Germany through August 2024, but asbestos bans in these countries suggest that these shipments were misclassified.
[4]Exports of unmanufactured asbestos fiber were reported by the U.S. Census Bureau in each year from 2020 through 2024 but these shipments likely consisted of materials misclassified as asbestos, reexports, and (or) waste products because asbestos has not been mined in the United States since 2002.
[5]To account for year-to-year fluctuations in chrysotile imports owing to cycles of companies replenishing and drawing down stockpiles, consumption was estimated as a 5-year rolling average of imports for consumption. Information regarding the quantity of industry stocks was unavailable.
[6]Defined as imports – exports. The United States has been 100% import reliant since 2002. All domestic consumption of chrysotile was from imports and unreported inventories.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]Export sales reported by the only producer of asbestos in Brazil. In February 2023, the Supreme Federal Court of Brazil confirmed a 2017 judgment that the extraction, sale, and use of asbestos were unconstitutional. Despite the ruling, a company in Brazil continued to mine asbestos, citing the authority of a State law that authorized extraction and processing for export purposes.

BARITE

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: In 2024, three companies mined barite at four operations in Nevada. Mine production increased, but data were withheld to avoid disclosing company proprietary data. An estimated 2.3 million tons of barite (from domestic production and imports) was sold by crushers and grinders operating in nine States.

Typically, more than 90% of the barite sold in the United States is used as a weighting agent in fluids used in the drilling of oil and natural gas wells. The majority of Nevada crude barite was ground in Nevada and then sold to companies drilling in the Central and Western United States. Because of the higher cost of rail and truck transportation compared to ocean freight, offshore drilling operations in the Gulf of Mexico and onshore drilling operations in other regions primarily used imported barite.

Barite also is used as a filler, extender, or weighting agent in products such as paints, plastics, and rubber. Some specific applications include use in automobile brake and clutch pads, in automobile paint primer for metal protection and gloss, as a weighting agent in rubber, and in the cement jacket around underwater petroleum pipelines. In the metal-casting industry, barite is part of the mold-release compounds. Because barite significantly blocks X-ray and gamma-ray emissions, it is used as aggregate in high-density concrete for radiation shielding around X-ray units in hospitals, nuclear powerplants, and university nuclear research facilities. Ultrapure barite is used as a contrast medium in X-ray and computed tomography examinations of the gastrointestinal tract.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production:					
Sold or used, mine	W	W	W	W	W
Ground and crushed[1]	1,410	1,670	2,220	2,260	2,300
Imports:[2]					
For consumption	1,480	1,660	2,330	2,420	2,000
General	869	1,440	1,890	2,220	1,900
Exports[3]	48	62	87	75	65
Consumption, apparent (crude and ground)[4]	W	W	W	W	W
Price, average unit value, ground, ex-works, dollars per metric ton	183	167	145	223	220
Employment, mine and mill, number[e]	360	330	380	440	440
Net import reliance[5] as a percentage of apparent consumption	>75	>75	>75	>75	>75

Recycling: None.

Import Sources (2020–23): India, 40%; China,[6] 25%; Morocco, 17%; Mexico, 14%; and other, 4%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Ground barite	2511.10.1000	Free.
Crude barite	2511.10.5000	$1.25 per metric ton.
Barium compounds:		
Barium oxide, hydroxide, and peroxide	2816.40.2000	2% ad valorem.
Barium chloride	2827.39.4500	4.2% ad valorem.
Barium sulfate, precipitated	2833.27.0000	0.6% ad valorem.
Barium carbonate, precipitated	2836.60.0000	2.3% ad valorem.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

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BARITE

Events, Trends, and Issues: Rig counts for oil and gas production are often used as an indicator of barite consumption. However, barite use per rig has been increasing owing to deeper oil and gas wells that require fewer rigs for oil and gas production. Through October 2024, the world annual average rig count excluding the United States was 1,169 compared with 1,154 in 2023. Increases in worldwide rig counts contributed to a slight increase in world barite production. At the beginning of 2024, the number of drill rigs[7] operating in the United States was 622; by the end of October 2024, the number of rigs operating had declined to 585. Rig counts remained 39% lower than that in the same period in 2019 before the global coronavirus disease 2019 (COVID-19) pandemic in 2020. Despite the slowing pace of domestic drill counts, barite sales were estimated to have increased slightly.

World Mine Production and Reserves: In response to concerns about dwindling global reserves of 4.2-specific-gravity barite used by the oil- and gas-drilling industry, the American Petroleum Institute issued an alternate specification for 4.1-specific-gravity weighting agents in 2010. Estimated reserves data were included only if developed since the adoption of the 4.1-specific-gravity standard. Reserves for China, Iran, and Turkey were revised based on company and Government reports.

	Mine production[e]		Reserves[8]
	2023	2024	
United States	W	W	NA
China	2,000	2,100	110,000
India	2,600	2,600	51,000
Iran	300	310	100,000
Kazakhstan	650	650	85,000
Laos	300	300	NA
Mexico	320	330	NA
Morocco	1,000	1,000	NA
Pakistan	130	130	NA
Russia	250	250	12,000
Turkey	[9]216	220	34,000
Other countries	314	320	NA
World total (rounded)	[10]8,080	[10]8,200	NA

World Resources:[8] In the United States, identified resources of barite were estimated to be 150 million tons, and undiscovered resources contributed an additional 150 million tons. The world's barite resources in all categories were about 2 billion tons, but only about 740 million tons were identified resources.

Substitutes: Owing to technical and economic factors, there are no large-scale alternatives to barite in oil- and gas-drilling fluids. Calcium carbonate, hematite, ilmenite, and manganese tetroxide are the most common alternatives used in specific circumstances. Some technical literature and patents also mention use of celestite, iron carbonate, and strontium carbonate, but these are not estimated to be widely used.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Imported and domestic barite, crushed and ground, sold or used by domestic grinding establishments.
[2]Includes data for the following Harmonized Tariff Schedule of the United States codes: 2511.10.1000, 2511.10.5000, and 2833.27.0000. General imports and imports for consumption data differ because of barite processed in free trade zones. General import data reports the form of imported barite at the time it entered the United States, whereas imports for consumption data reports crude barite processed in free trade zones as ground. Imports for consumption may not be immediately reported depending on processing time.
[3]Includes data for the following Schedule B numbers: 2511.10.1000 and 2833.27.0000.
[4]Defined as mine production (sold or used) + imports for consumption – exports.
[5]Defined as imports for consumption – exports.
[6]Includes Hong Kong.
[7]Source: Baker Hughes Co., 2024, North America rotary rig count: Baker Hughes Co. (Accessed October 24, 2024, at https://bakerhughesrigcount.gcs-web.com/na-rig-count.)
[8]See Appendix C for resource and reserve definitions and information concerning data sources.
[9]Reported.
[10]Excludes U.S. production.

BAUXITE AND ALUMINA[1]

(Data in thousand metric dry tons unless otherwise specified)

Domestic Production and Use: In 2024, a limited amount of bauxite and bauxitic clay was produced for nonmetallurgical use in Arkansas and Georgia. Production statistics were withheld for bauxite and estimated for alumina to avoid disclosing company proprietary data. In 2024, the reported quantity of bauxite consumed was estimated to be 1.8 million tons, 12% less than that reported in 2023, with an estimated value of about $54 million. About 76% of the bauxite consumed was refined by the Bayer process for alumina or aluminum hydroxide, and the remainder went to products such as abrasives, cement, chemicals, proppants, and refractories, and as a slag adjuster in steel mills. Alumina production was estimated to be 810,000 tons, 5% less than that in 2023. About 69% of the alumina produced went to primary aluminum smelters, and the remainder went to nonmetallurgical products, such as abrasives, ceramics, chemicals, and refractories.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Bauxite:					
Production, mine	W	W	W	W	W
Imports for consumption[2]	3,760	3,880	3,630	3,160	2,800
Exports[2]	16	13	10	14	13
Stocks, industry, yearend[e, 2]	250	200	200	240	250
Consumption:					
Apparent[3]	W	W	W	W	W
Reported	3,330	2,790	2,170	2,050	1,800
Price, average unit value of imports, free alongside ship (f.a.s.), dollars per metric ton	30	31	32	31	30
Net import reliance[4] as a percentage of apparent consumption	>75	>75	>75	>75	>75
Alumina:					
Production, refinery[e, 5]	1,300	1,000	920	850	810
Imports for consumption[5]	1,340	1,550	1,880	1,360	1,300
Exports[5]	153	180	174	139	150
Stocks, industry, yearend[5]	234	202	194	190	180
Consumption, apparent[3]	2,530	2,410	2,640	2,080	2,000
Price, average unit value of imports, f.a.s., dollars per metric ton	394	462	518	481	570
Net import reliance[4] as a percentage of apparent consumption	49	58	65	59	59

Recycling: None.

Import Sources (2020–23): Bauxite:[2] Jamaica, 67%; Turkey, 9%; Guyana, 8%; Australia, 6%; and other, 10%. Alumina:[5] Brazil, 68%; Jamaica, 10%; Australia, 7%; Canada, 5%; and other, 10%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Bauxite, calcined (refractory grade)	2606.00.0030	Free.
Bauxite, calcined (other)	2606.00.0060	Free.
Bauxite, crude dry (metallurgical grade)	2606.00.0090	Free.
Aluminum oxide (alumina)	2818.20.0000	Free.
Aluminum hydroxide	2818.30.0000	Free.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile: None.

Events, Trends, and Issues: In 2024, one domestic alumina refinery produced alumina from imported bauxite. A 1.2-million-ton-per-year alumina refinery in Gramercy, LA, produced alumina for aluminum smelting and specialty-grade alumina. A 500,000-ton-per-year alumina refinery in Burnside, LA, was temporarily shut down in August 2020 and remained idle in 2024. No plans were announced regarding its reopening. The average prices, f.a.s., for U.S. imports for consumption of crude dry bauxite and metallurgical-grade alumina during the first 8 months of 2024 were $30 per ton and $560 per ton, 5% less and 12% more than those in the same period in 2023, respectively.

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BAUXITE AND ALUMINA

A United States-based multinational aluminum producer acquired full control of an Australia-based joint-venture that mined bauxite and produced alumina and aluminum globally. An India-based aluminum producer increased production at its newly expanded alumina refinery in Odisha, to 3.5 million tons per year. In Australia, a 2.2-million-ton-per-year alumina refinery located in Western Australia was idled owing to market conditions and operating costs. A fire at a natural gas pipeline in Queensland, Australia, caused an alumina refinery to declare force majeure. An Indonesia-based mining company began production at its 2.2-million-ton-per-year alumina refinery in the Province of West Kalimantan. A 1.7-million-ton-per-year alumina refinery in Ukraine has remained closed since 2022 owing to the Russia-Ukraine conflict.

World Alumina Refinery and Bauxite Mine Production and Bauxite Reserves: Reserves for China, Indonesia, Kazakhstan, Turkey, and Vietnam were revised based on company and Government reports.

	Alumina production[5]		Bauxite production		Bauxite reserves[6]
	2023	2024[e]	2023	2024[e]	
United States	[e]850	720	W	W	20,000
Australia	18,800	18,000	104,000	100,000	[7]3,500,000
Brazil	[e]11,000	11,000	[e]32,000	33,000	2,700,000
Canada	1,500	1,500	—	—	—
China	82,400	84,000	[e]91,000	93,000	680,000
Germany	[e]900	960	—	—	—
Greece	869	860	[e]1,200	1,200	—
Guinea	273	300	123,000	130,000	7,400,000
India	[e]7,500	7,600	23,400	25,000	650,000
Indonesia	[e]1,200	1,300	[e]30,000	32,000	2,800,000
Ireland	1,380	1,600	—	—	—
Jamaica	1,400	1,500	6,000	6,100	2,000,000
Kazakhstan	1,300	1,400	4,560	4,900	280,000
Russia	3,020	2,900	[e]5,800	6,300	480,000
Saudi Arabia	1,830	1,800	[e]5,400	5,800	180,000
Spain	716	820	—	—	—
Turkey	300	320	2,940	3,200	69,000
United Arab Emirates	2,480	2,400	—	—	—
Vietnam	1,490	1,500	[e]3,920	4,200	3,100,000
Other countries	1,300	1,500	5,260	5,700	5,300,000
World total (rounded)	141,000	142,000	[8]438,000	[8]450,000	29,000,000

World Resources:[6] Bauxite resources are estimated to be between 55 billion and 75 billion tons, distributed in Africa (32%), Oceania (23%), South America and the Caribbean (21%), Asia (18%), and elsewhere (6%). Domestic resources of bauxite are inadequate to meet long-term U.S. demand, but the United States and most other major aluminum-producing countries have essentially inexhaustible subeconomic resources of aluminum in materials other than bauxite.

Substitutes: Bauxite is the only raw material used in the production of alumina on a commercial scale in the United States. Although currently not economically competitive with bauxite, vast resources of clay are technically feasible sources of alumina. Other raw materials, such as alunite, anorthosite, coal wastes, and oil shales, offer additional potential alumina sources. Synthetic mullite, produced from kaolin, bauxitic kaolin, kyanite, and sillimanite, substitutes for bauxite-based refractories. Silicon carbide and alumina zirconia can substitute for alumina and bauxite in abrasives but cost more.

[e]Estimated. W Withheld to avoid disclosing company proprietary data. — Zero.

[1]See also the Aluminum chapter. As a general rule, 4 tons of dried bauxite is required to produce 2 tons of alumina, which, in turn, can be used to produce 1 ton of aluminum.

[2]Includes all forms of bauxite, expressed as dry equivalent weights.

[3]Defined as production + imports – exports ± adjustments for industry stock changes.

[4]Defined as imports – exports ± adjustments for industry stock changes.

[5]Calcined equivalent weights.

[6]See Appendix C for resource and reserve definitions and information concerning data sources.

[7]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 1.6 billion tons.

[8]Excludes U.S. production.

BERYLLIUM

(Data in metric tons, beryllium content, unless otherwise specified)

Domestic Production and Use: One company in Utah mined bertrandite ore and converted it, along with imported beryl, into beryllium hydroxide. Some of the beryllium hydroxide was shipped to the company's plant in Ohio, where it was converted into metal, oxide, and downstream beryllium-copper master alloy, and some was sold. Estimated beryllium apparent consumption in 2024 was 170 tons and was valued at about $260 million based on the most recent beryllium price estimate. Based on sales revenues, approximately 20% of beryllium products were used in industrial components, 19% in aerospace and defense applications, 11% in automotive electronics, 8% in telecommunications infrastructure, 6% each in consumer electronics and energy applications, 2% in semiconductor applications, and 28% in other applications. Beryllium alloy strip and bulk products, the most common forms of processed beryllium, were used in all application areas. Most unalloyed beryllium metal and beryllium composite products were used in defense and scientific applications. The U.S. Department of Defense supports the availability of domestic beryllium to meet critical defense needs. In 2010, under the Defense Production Act, Title III program, a public-private partnership with the leading U.S. beryllium producer reestablished domestic production of beryllium metal.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, mine shipments	165	175	175	185	180
Imports for consumption[1]	48	49	39	25	20
Exports[2]	25	30	61	68	30
Shipments from Government stockpile[3]	3	7	9	NA	NA
Consumption:					
Apparent[4]	196	196	187	144	170
Reported, ore	170	170	170	180	180
Price, annual average unit value, beryllium-copper master alloy,[5] dollars per kilogram of contained beryllium	620	680	660	1,400	1,500
Stocks, ore, industry, yearend	30	35	10	10	10
Net import reliance[6] as a percentage of apparent consumption	16	11	6	E	E

Recycling: Beryllium was recovered from new scrap generated during the manufacture of beryllium products and from old scrap. Detailed data on the quantities of beryllium recycled were not available but may account for as much as 20% to 25% of total beryllium consumption. The leading U.S. beryllium producer managed a recycling program for all its beryllium products, recovering approximately 40% of the beryllium content of the new and old beryllium alloy scrap.

Import Sources (2020–23):[1] Kazakhstan, 39%; Latvia, 23%; Japan, 17%; Canada, 6%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Beryllium ores and concentrates	2617.90.0030	Free.
Beryllium oxide and hydroxide	2825.90.1000	3.7% ad valorem.
Beryllium-copper master alloy	7405.00.6030	Free.
Beryllium-copper plates, sheets, and strip:		
Thickness of 5 millimeters (mm) or more	7409.90.1030	3% ad valorem.
Thickness of less than 5 mm:		
Width of 500 mm or more	7409.90.5030	1.7% ad valorem.
Width of less than 500 mm	7409.90.9030	3% ad valorem.
Beryllium:		
Unwrought, including powders	8112.12.0000	8.5% ad valorem.
Waste and scrap	8112.13.0000	Free.
Other	8112.19.0000	5.5% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

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BERYLLIUM

Government Stockpile:[7]

Material	FY 2024 Potential acquisitions	FY 2024 Potential disposals	FY 2025 Potential acquisitions	FY 2025 Potential disposals
Metal (all types)	—	7	—	7

Events, Trends, and Issues: Apparent consumption in 2024 increased by 18% from that in 2023 owing primarily to a 56% decrease in estimated beryllium exports offset by a 20% decrease in estimated imports. The decrease in exports reflected a large reduction in beryllium metal exports to Canada, Germany, Japan, and Mexico. The decrease in imports reflected a reduction in beryllium metal imports from Belgium, Kazakhstan, and Latvia. During the first 6 months of 2024, the leading U.S. beryllium producer reported that net sales of its beryllium alloy strip and bulk products and beryllium metal and composite products were 4% lower than those during the first 6 months of 2023. Net sales of beryllium products decreased primarily in the automotive, industrial components, and telecommunications and data markets. Because of the toxic nature of beryllium, various international, national, and State guidelines and regulations have been established regarding beryllium in air, water, and other media. Industry is required to carefully control the quantity of beryllium dust, fumes, and mists in the workplace.

World Mine Production and Reserves:

	Mine production[8, 9] 2023	Mine production[8, 9] 2024[e]
United States	185	180
Brazil	[e]40	80
China	[e]74	77
Madagascar	[e]1	1
Mozambique	23	24
Rwanda	[e]1	1
Uganda	[e]1	1
World total (rounded)	325	360

Reserves[10]

The United States has very little beryl that can be economically hand sorted from pegmatite deposits. An epithermal deposit in the Spor Mountain area in Utah is a large bertrandite resource, which is being mined. Proven and probable bertrandite reserves in Utah total about 19,000 tons of beryllium content. World beryllium reserves were not available.

World Resources:[10] The world's identified resources of beryllium have been estimated to be more than 100,000 tons. About 60% of these resources are in the United States; by tonnage, the Spor Mountain area in Utah, the McCullough Butte area in Nevada, the Black Hills area in South Dakota, the Sierra Blanca area in Texas, the Seward Peninsula in Alaska, and the Gold Hill area in Utah account for most of the total.

Substitutes: Because the cost of beryllium is high compared with that of other materials, it is used in applications in which its properties are crucial. In some applications, certain metal matrix or organic composites, high-strength grades of aluminum, pyrolytic graphite, silicon carbide, steel, or titanium may be substituted for beryllium metal or beryllium composites. Copper alloys containing nickel and silicon, tin, titanium, or other alloying elements or phosphor bronze alloys (copper-tin-phosphorus) may be substituted for beryllium-copper alloys, but these substitutions can result in substantially reduced performance. Aluminum nitride or boron nitride may be substituted for beryllium oxide.

[e]Estimated. E Net exporter. NA Not available. — Zero.

[1]Includes estimated beryllium content of imported ores and concentrates, oxide and hydroxide, unwrought metal (including powders), beryllium articles, waste and scrap, beryllium-copper master alloy, and beryllium-copper plates, sheets, and strip.

[2]Includes estimated beryllium content of exported unwrought metal (including powders), beryllium articles, and waste and scrap.

[3]Change in total inventory from prior yearend inventory. If negative, increase in inventory. Beginning in 2023, Government stock changes no longer available.

[4]Defined for 2020–22 as production + imports − exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.

[5]Calculated from gross weight and customs value of imports; beryllium content estimated to be 4%. Rounded to two significant figures.

[6]Defined for 2020–22 as imports − exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.

[7]See Appendix B for definitions.

[8]In addition to the countries listed, Kazakhstan and Portugal may have produced beryl ore, but available information was inadequate to make reliable estimates of output. Other nations that produced gemstone beryl ore may also have produced some industrial beryl ore.

[9]Based on 4% beryllium content of bertrandite and beryl sources.

[10]See Appendix C for resource and reserve definitions and information concerning data sources.

BISMUTH

(Data in metric tons unless otherwise specified)

Domestic Production and Use: The United States ceased production of primary refined bismuth in 1997 and is highly import reliant. Bismuth is contained in some lead ores mined domestically. However, the last domestic primary lead smelter closed at yearend 2013; since then, all lead concentrates have been exported for smelting.

Most domestic bismuth consumption was for chemicals used in cosmetic, industrial, laboratory, and pharmaceutical applications. Bismuth use in pharmaceuticals included bismuth subsalicylate (the active ingredient in over-the-counter stomach remedies) and other compounds used to treat burns, intestinal disorders, and stomach ulcers. Bismuth compounds such as bismuth nitrate, bismuth oxychloride, and bismuth vanadate are also used in industrial applications for the manufacture of ceramic glazes, crystalware, high-performance pigments, and pearlescent pigments.

Bismuth has a wide variety of metallurgical applications, including use as an additive to improve metal integrity of malleable cast iron in the foundry industry and as a nontoxic replacement for lead in brass, free-machining aluminum alloys and steels, and solders. The use of bismuth in brass for pipe fittings, fixtures, and water meters increased after 2014, when the definition of “lead-free” under the Safe Drinking Water Act was modified to reduce the maximum lead content of “lead-free” pipes and plumbing fixtures to 0.25% from 8%. The melting point of bismuth is relatively low at 271 degrees Celsius. Bismuth is an important component of various fusible alloys that can be used in holding devices for grinding optical lenses, as plugs for abandoned oil wells, as a temporary filler to prevent damage to tubes in bending operations, as a triggering mechanism for fire sprinklers, and in other applications in which a low melting point is ideal. Bismuth-tellurium-oxide alloy film paste is used in the manufacture of semiconductor devices.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Refinery	—	—	—	—	—
Secondary (scrap)[e]	80	80	80	80	80
Imports for consumption, metal, alloys, and scrap:					
Containing more than 99.99% bismuth, by weight	NA	NA	740	731	650
Other	NA	NA	2,340	1,110	1,200
Total[1]	1,650	1,980	3,080	1,840	1,800
Exports, metal, alloys, and scrap:					
Containing more than 99.99% bismuth, by weight	NA	NA	144	131	560
Other	NA	NA	360	329	600
Total[2]	699	1,010	503	460	1,200
Consumption:					
Apparent[3]	1,210	1,030	2,600	1,450	760
Reported	513	597	724	691	700
Price, average,[4] dollars per pound	2.73	3.74	3.90	4.08	5.30
Stocks, yearend, consumer, bismuth metal	271	297	356	365	365
Net import reliance[5] as a percentage of apparent consumption	93	92	97	94	89

Recycling: Recycled bismuth-containing alloy scrap was thought to compose up to 3% to 10% of U.S. bismuth apparent consumption for the years 2020–24.

Import Sources (2020–23): China,[6] 67%; Republic of Korea, 23%; and other, 10%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Bismuth and articles thereof, including waste and scrap:		
Containing more than 99.99% of bismuth, by weight	8106.10.0000	Free.
Other	8106.90.0000	Free.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile: None.

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BISMUTH

Events, Trends, and Issues: In 2024, average monthly prices for bismuth (in-warehouse, Rotterdam) increased from $3.89 per pound in January to $6.29 per pound in October. The estimated annual average price in 2024 was $5.30 per pound, a 30% increase from that in 2023, and the highest annual average price since 2018. Bismuth metal prices have been increasing worldwide and particularly in China since 2023. China, the leading producer and exporter of bismuth, reportedly experienced high feedstock prices as competition for bismuth ore increased among domestic smelters. United States bismuth metal imports (under Harmonized System code 8106) from China decreased by 40% to 580 tons in 2024 from 964 tons in 2023.

Estimated world production of bismuth was 16,000 tons in 2024 compared with 16,200 tons in 2023. Reported bismuth production capacities were unavailable.

World Refinery Production and Capacity:

	Refinery production[e]		Production capacity
	2023	2024[e]	
United States	—	—	NA
Bolivia	68	70	NA
Bulgaria	46	50	NA
China	13,300	13,000	NA
Japan	500	500	NA
Kazakhstan	180	180	NA
Korea, Republic of	1,000	1,000	NA
Laos	[8]1,150	1,100	NA
World total (rounded)	16,200	16,000	NA

World Resources:[7] Bismuth reserves and resources data were generally not reported at a mine or country level and thus difficult to quantify. Bismuth minerals rarely occur in sufficient quantities to be mined as principal products; bismuth is produced most often as a byproduct during the processing of lead ores. In China and Vietnam, bismuth is also produced as a byproduct or coproduct of tungsten and other metal ore processing. In Japan and the Republic of Korea, bismuth is produced as a byproduct or coproduct of zinc ore processing. The Tasna Mine in Bolivia, which has been inactive since 1996, and a mine in China are the only mines where bismuth has been the primary product.

Substitutes: Bismuth compounds can be replaced in pharmaceutical applications by alumina, antibiotics, calcium carbonate, and magnesia. Titanium-dioxide-coated mica flakes and fish-scale extracts are substitutes in certain pigment uses. Cadmium, indium, lead, and tin can partially replace bismuth in low-temperature solders. Resins can replace bismuth alloys for holding metal shapes during machining, and glycerin-filled glass bulbs can replace bismuth alloys in triggering devices for fire sprinklers. Free-machining alloys can contain lead, selenium, or tellurium as a replacement for bismuth. Bismuth is an environmentally friendly substitute for lead in plumbing and many other applications, including fishing weights, hunting ammunition, lubricating greases, and soldering alloys.

[e]Estimated. NA Not available. — Zero.

[1]Includes data for the following Harmonized Tariff Schedule of the United States codes: 8106.00.0000 (for the years 2020–21), and 8106.10.0000 and 8106.90.0000 (for the years 2022–24).

[2]Includes data for the following Schedule B numbers: 8106.00.0000 (for the years 2020–21), and 8106.10.0000 and 8106.90.0000 (for the years 2022–24).

[3]Defined as secondary production + imports – exports ± adjustments for industry stock changes.

[4]Prices are based on 99.99%-purity metal at warehouse (Rotterdam) in minimum lots of 1 ton. Source: Fastmarkets.

[5]Defined as imports – exports ± adjustments for industry stock changes.

[6]Includes Hong Kong.

[7]See Appendix C for resource and reserve definitions and information concerning data sources.

[8]Reported.

BORON

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: Three companies in southern California produced borates in 2024, and most of the boron products consumed in the United States were manufactured domestically. Estimated boron production increased in 2024 compared with production in 2023. U.S. boron production and consumption data were withheld to avoid disclosing company proprietary data. The leading boron producer mined borate ores, which contain the minerals kernite, tincal, and ulexite, by open pit methods and operated associated compound plants. Kernite was used to produce boric acid, tincal was used to produce sodium borate, and ulexite was used as a primary ingredient in the manufacture of a variety of specialty glasses and ceramics. A second company produced borates from brines extracted through solution-mining techniques. A third company began mining borates using solution mining techniques in January 2024. Boron minerals and chemicals were principally consumed in the north-central and eastern United States. In 2024, the glass and ceramics industries remained the leading domestic users of boron products. Boron also was used as a component in abrasives, cleaning products, insecticides, insulation, and in the production of semiconductors.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production	W	W	W	W	W
Imports for consumption:					
Refined borax	174	232	168	156	160
Boric acid	39	54	48	38	42
Colemanite (calcium borates)	18	3	1	2	1
Ulexite (sodium borates)	41	49	38	20	37
Exports:					
Boric acid	257	280	239	253	240
Refined borax	594	607	651	604	590
Consumption, apparent[1]	W	W	W	W	W
Price, average unit value of imports, cost, insurance, and freight, dollars per metric ton	380	394	485	606	560
Employment, number	1,330	1,330	1,400	1,430	1,500
Net import reliance[2] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2020–23): All forms: Turkey, 90%; Bolivia, 6%; and other, 4%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–24**
Natural borates:		
Sodium (ulexite)	2528.00.0005	Free.
Calcium (colemanite)	2528.00.0010	Free.
Boric acids	2810.00.0000	1.5% ad valorem.
Borates, refined borax:		
Anhydrous	2840.11.0000	0.3% ad valorem.
Non-anhydrous	2840.19.0000	0.1% ad valorem.

Depletion Allowance: Borax, 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Elemental boron is a metalloid with limited commercial applications. Although the term "boron" is commonly referenced, it does not occur in nature in an elemental state. Boron combines with oxygen and other elements to form boric acid or inorganic salts called borates. Boron compounds, chiefly borates, are commercially important; therefore, boron products are priced and sold based on their boric oxide (B_2O_3) content, varying by ore and compound and by the absence or presence of calcium and sodium. Four borate minerals—colemanite, kernite, tincal, and ulexite—account for 90% of the borate minerals used by industry worldwide. Although borates were used in more than 300 applications, more than three-quarters of world consumption was used in ceramics, detergents, fertilizers, and glass.

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BORON

China, India, Canada, Indonesia, and Mexico, in decreasing order of tonnage, were the countries that imported the largest quantities of refined borates from the United States in 2024. Domestic shipments of boric acid were sent to China, the Netherlands, the Republic of Korea, Taiwan, and Brazil, in decreasing order of tonnage. Because China has low-grade boron reserves and demand for boron is anticipated to rise in that country, imports from the United States were expected to remain steady during the next several years.

Interests and investments in boron derivatives continued domestically and abroad. The U.S. Department of Defense under the Defense Production Act, Title III, awarded $49.6 million to a company headquartered in Golden, CO, in December 2023. The funding was to be used to increase domestic boron carbide production capacity. In April 2024, a domestic company began boric acid production at its small-scale boron facility in Newberry Springs, CA. It began mining borates in January 2024. This facility's initial production capacity was about 1,800 tons per year, and the company planned to increase production to about 8,200 tons per year in the future. The small-scale boron facility was expected to focus on specialty boron products for industries related to defense, electric transportation, food security, and global decarbonization.

One Australia-based mine developer progressed toward construction of its boric acid project in Nevada. In September 2024, the Bureau of Land Management completed its final environmental impact statement and determined that development of the project may proceed. Once constructed, the project was expected to have a 26-year mine life and produce about 175,000 tons per year of boric acid. Initial production was expected to begin in 2028.

About 18 months after opening its first boron carbide facility in March 2023, Turkey opened another boron facility, the Bigadiç Granular Boron Production Facility, in September 2024. The new facility was expected to primarily produce granulated pipes for the fertilizer industry. This facility has a production capacity of 35,000 tons per year. By the end of August 2024, borate production in Turkey had increased by 36% compared with that in the same period in 2023.

World Production and Reserves: Reserve data for China were revised based on Government reports.

	Production—All forms[e]		Reserves[3]
	2023	2024	
United States	W	W	48,000
Argentina, crude ore	160	160	NA
Bolivia, ulexite	140	230	NA
Chile, ulexite	420	420	35,000
China, boric oxide equivalent	300	340	9,100
Germany, compounds	38	40	NA
Peru, crude borates	300	300	4,000
Russia, datolite ore	80	80	40,000
Turkey, refined borates	2,500	3,000	950,000
World total[4]	XX	XX	XX

World Resources:[3] Deposits of borates are associated with volcanic activity and arid climates, with the largest economically viable deposits in the Mojave Desert of the United States, the Alpide belt along the southern margin of Eurasia, and the Andean belt of South America. U.S. deposits consist primarily of tincal, kernite, and borates contained in brines, and to a lesser extent, ulexite and colemanite. About 70% of all deposits in Turkey are colemanite, primarily used in the production of heat-resistant glass. At current levels of consumption, world resources are adequate for the foreseeable future.

Substitutes: The substitution of other materials for boron is possible in detergents, enamels, insulation, and soaps. Sodium percarbonate can replace borates in detergents and requires lower temperatures to undergo hydrolysis, which is an environmental consideration. Some enamels can use other glass-producing substances, such as phosphates. Insulation substitutes include cellulose, foams, and mineral wools. In soaps, sodium and potassium salts of fatty acids can act as cleaning and emulsifying agents.

[e]Estimated. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Defined as production + imports – exports.
[2]Defined as imports – exports.
[3]See Appendix C for resource and reserve definitions and information concerning data sources.
[4]World totals cannot be calculated because production and reserves are not reported in a consistent manner by all countries.

BROMINE

(Data in metric tons, bromine content, unless otherwise specified)

Domestic Production and Use: Bromine was recovered from underground brines by two companies in Arkansas. Bromine is one of the leading mineral commodities, in terms of value, produced in Arkansas. The two bromine companies in the United States account for a large percentage of world production capacity.

The leading global applications of bromine are for the production of brominated flame retardants (BFRs) and clear brine drilling fluids. Bromine compounds also are used in a variety of other applications, including industrial uses, as intermediates, and for water treatment. U.S. apparent consumption of bromine in 2024 was estimated to be more than that in 2023.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production	W	W	W	W	W
Imports for consumption, elemental bromine and compounds[1]	30,700	27,200	36,500	50,800	61,000
Exports, elemental bromine and compounds[2]	36,600	27,900	19,400	38,900	34,000
Consumption, apparent[3]	W	W	W	W	W
Price, average unit value of imports (cost, insurance, and freight), dollars per kilogram, bromine content	2.67	2.85	3.29	2.92	2.70
Employment, number[e]	1,100	1,100	1,100	1,100	1,100
Net import reliance[4] as a percentage of apparent consumption	E	E	<25	<25	<25

Recycling: Some bromide solutions were recycled to obtain elemental bromine and to prevent the solutions from being disposed of as hazardous waste. For example, hydrogen bromide is emitted as a byproduct of several organic reactions; this byproduct can be recycled with virgin bromine brines and used as a source of bromine production. Bromine contained in plastics, such as BFRs, can be difficult and costly to remove because the BFR is often bound to the polymer or resin matrix; therefore, bromine will often be recycled via the parent polymer with the polymer used again in new products. The stability of BFRs may reduce or eliminate the need for incorporating additional flame retardants into new products made from recycled plastic because the recycled plastic may meet the same levels of fire safety as the virgin material. However, this stability may lead to the unintentional reintroduction of bromine or BFRs into new plastic product cycles. Bromine used in zinc-bromine batteries can be removed and completely recovered as bromine at the battery's end of life, purified, and used for new batteries. Available information was insufficient to estimate the quantity of bromine recovered and recycled.

Import Sources (2020–23):[5] Israel, 83%; Jordan, 9%; China,[6] 3%; and other, 5%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–23**
Bromine	2801.30.2000	5.5% ad valorem.
Hydrobromic acid	2811.19.3000	Free.
Potassium or sodium bromide	2827.51.0000	Free.
Ammonium, calcium, or zinc bromide	2827.59.2500	Free.
Potassium bromate	2829.90.0500	Free.
Sodium bromate	2829.90.2500	Free.
Methyl bromide[7]	2903.61.0000	Free.
Ethylene dibromide[8]	2903.62.1000	5.4% ad valorem.
Dibromoneopentylglycol	2905.59.3000	Free.
Tetrabromobisphenol A	2908.19.2500	5.5% ad valorem.
Decabromodiphenyl and octabromodiphenyl oxide	2909.30.0700	5.5% ad valorem.

Depletion Allowance: Brine wells, 5% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The United States maintained its position as one of the leading bromine producers in the world along with China, Israel, and Jordan. In 2024, estimated total imports of bromine and bromine compounds (bromine content) increased by 20% from those in 2023, and the leading source of imports of bromine and bromide compounds (gross weight) through July 2024 was Israel (87%), followed by Jordan (10%). The average annual unit value of imported bromine and bromine compounds (bromine content) was approximately $2.70 per kilogram, which was 8% less than that in 2023. Together, the leading imported bromine products in terms of both gross weight and bromine content were bromides and bromide oxides of ammonium, calcium, or zinc and bromides of sodium or potassium, accounting for more than 90% of total imported bromine.

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BROMINE

In 2024, estimated total exports (bromine content) decreased by 13% compared with those in 2023, and the leading destinations for exports (gross weight) through July 2024 were Guyana (29%), Saudi Arabia (25%), and the United Kingdom (14%). The average annual unit value of exported bromine and bromine compounds (bromine content) was approximately $3.30 per kilogram, compared with $3.28 per kilogram in 2023.

In July 2024, the U.S. Food and Drug Administration (FDA) revoked the authorization for brominated vegetable oil (BVO) to be used as a food additive. BVO had been used to stabilize fruit flavoring oils in fruit-flavored beverages since the 1920s. It was classified as generally recognized as safe (GRAS) by the FDA until 1970 when it lost its GRAS classification owing to toxicity concerns. Based on available information at the time, the FDA approved its continued use at a maximum level of 15 parts per million in beverages compared with the previous maximum level of 150 parts per million. A more recent collaborative study demonstrated that a safe level of dietary BVO could not be established; therefore, there was no longer a reasonable certainty of no harm from the use of BVO as a stabilizer in flavoring oils.[9]

World Production and Reserves: Reserves for Jordan were revised based on company reports.

	Production[e]		Reserves[10]
	2023	2024	
United States	W	W	11,000,000
China	[11]101,000	100,000	130,000
India	6,900	7,000	NA
Israel	[11]143,000	140,000	Large
Japan	20,000	20,000	NA
Jordan	[11]116,000	120,000	360,000
Ukraine	8,000	8,000	NA
World total (rounded)	[12]395,000	[12]400,000	Large

World Resources:[10] Bromine is found principally in seawater, evaporitic (salt) lakes, and underground brines associated with petroleum deposits. Seawater contains about 65 parts per million bromine, or an estimated 100 trillion tons. The Dead Sea, in the Middle East, is estimated to contain 1 billion tons of bromine. Bromine also is recovered from seawater as a coproduct during evaporation to produce salt.

Substitutes: Chlorine and iodine may be substituted for bromine in a few chemical reactions and for sanitation purposes. There are no comparable substitutes for bromine in various oil- and gas-well-completion and packer applications. Because plastics have a low ignition temperature, aluminum hydroxide, magnesium hydroxide, organic chlorine compounds, and phosphorus compounds can be substituted for bromine as fire retardants in some uses.

[e]Estimated. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Includes data for the Harmonized Tariff Schedule of the United States codes shown in the “Tariff” section.
[2]Includes data for the following Schedule B numbers: 2801.30.2000, 2827.51.0000, and 2827.59.0000 (for the years 2020–24); 2903.31.0000 and 2903.39.1520 (for the years 2020–21); and 2903.61.0000 and 2903.62.1000 (for the years 2022–24).
[3]Defined as production (sold or used) + imports – exports.
[4]Defined as imports – exports.
[5]Calculated using the gross weight of imports.
[6]Includes Hong Kong.
[7]Prior to 2022, was listed under Harmonized Tariff Schedule of the United States code 2903.39.1520.
[8]Prior to 2022, was listed under Harmonized Tariff Schedule of the United States code 2903.31.0000.
[9]Source: U.S. Food and Drug Administration, 2024, Revocation of authorization for use of brominated vegetable oil in food: Federal Register, v. 89, no. 128, July 3, p. 55040–55045. (Accessed September 25, 2024, at https://www.govinfo.gov/content/pkg/FR-2024-07-03/pdf/2024-14300.pdf.)
[10]See Appendix C for resource and reserve definitions and information concerning data sources.
[11]Reported.
[12]Excludes U.S. production.

CADMIUM

(Data in metric tons unless otherwise specified)

Domestic Production and Use: One company operating in Tennessee recovered an estimated 300 tons of primary cadmium metal valued at $1.2 million as a byproduct of zinc leaching from roasted sulfide concentrates at the only domestic zinc smelter. In 2024, with a shift in focus to lithium-ion battery recycling, a company in Ohio that had been recovering secondary cadmium metal shut down its nickel cadmium (NiCd) battery recycling line. Another battery recycling company, established in Ohio in 2022, processed both consumer and industrial NiCd batteries for salable metals and was recovering cadmium metal in 2024 and planned to refine it to battery-grade purity. Cadmium metal and compounds are mainly consumed for NiCd batteries, but also for alloys, coatings, and pigments. An increasing use for cadmium was in cadmium-telluride (CdTe) thin-film solar panels, and in cadmium-zinc-telluride (CdZnTe) substrates for radiation detectors and imaging applications.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Primary, refined[1]	211	241	212	375	300
Secondary	W	W	W	W	W
Imports for consumption:					
Unwrought cadmium and powders	282	155	99	72	7
Wrought cadmium and other articles	3	2	1	1	3
Cadmium waste and scrap	90	85	40	([2])	26
Cadmium oxide	28	14	33	37	17
Cadmium sulfide	4	—	([2])	—	20
Cadmium pigments and preparations based on cadmium compounds	69	101	146	147	120
Exports:					
Unwrought cadmium and powders	4	51	68	100	20
Wrought cadmium and other articles	482	217	60	21	30
Cadmium waste and scrap	([2])	—	2	14	—
Cadmium pigments and preparations based on cadmium compounds	2,120	550	747	947	500
Consumption of metal, apparent[3]	W	W	W	W	W
Price, metal, annual average,[4] dollars per kilogram	2.29	2.56	3.42	4.06	4.1
Net import reliance[5] as a percentage of apparent consumption	<75	<50	<25	E	E

Recycling: Secondary cadmium is mainly recovered from spent consumer and industrial NiCd batteries. Other waste and scrap from which cadmium can be recycled includes copper-cadmium alloy scrap, some complex nonferrous alloy scrap, cadmium-containing dust from electric-arc furnaces, and CdTe solar panels.

Import Sources (2020–23):[6] China,[7] 34%; Germany, 31%; Australia, 23%; Peru, 10%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Cadmium oxide	2825.90.7500	Free.
Cadmium sulfide	2830.90.2000	3.1% ad valorem.
Pigments and preparations based on cadmium compounds	3206.49.6010	3.1% ad valorem.
Cadmium waste and scrap	8112.61.0000	Free.
Unwrought cadmium and powders	8112.69.1000	Free.
Wrought cadmium and other articles	8112.69.9000	4.4% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile:[8] The fiscal year (FY) 2025 potential acquisitions include 2,800 square centimeters of CdZnTe substrates, a 180% increase from 1,000 square centimeters in FY 2024.

Events, Trends, and Issues:

For the second consecutive year, the United States was a net exporter of cadmium. Average prices for cadmium decreased midyear, reflecting the seasonal buying patterns in India, and ended the year higher than those in January. India was the leading importer of cadmium metal; more than 11,400 tons were imported in 2023, and almost 6,000 tons as of August 2024. Though significant quantities of cadmium sponge were produced in India as a

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CADMIUM

byproduct of zinc smelting, no production of cadmium metal was reported as of August 2024 in monthly statistics published by the Indian Bureau of Mines. Based on estimated production of cadmium as well as imports and exports, China replaced India as the leading consumer of cadmium in 2024.

Cadmium use in semiconductors continued to increase, especially CdTe in thin-film solar panels. The Inflation Reduction Act of 2022 provided tax incentives to transition to clean energy including for the domestic manufacturing of solar modules and components. The leading domestic CdTe solar panel manufacturer, based in Ohio, began commercial production in the third quarter of 2024 at a fourth facility, located in Alabama, that increased manufacturing capacity to almost 11 gigawatts (GW) per year. A fifth site was under construction in Louisiana and was expected to add another 3.5 GW per year in the second half of 2025. Worldwide, capacity was about 21 GW per year including a facility in India that opened in early 2024. In January, the National Renewable Energy Laboratory, administrator of the 3-year Cadmium Telluride Photovoltaics Accelerator Program, announced that $1.8 million had been awarded in a second round of contracts to support development of CdTe solar cells that would be more efficient and have a lower cost.

World Refinery Production and Reserves:

	Refinery production[e]		Reserves[9]
	2023	2024	
United States[1]	[10]375	300	Quantitative estimates of reserves were not available. The cadmium content of typical zinc ores averages about 0.03%. See the Zinc chapter for zinc reserves.
Australia	900	900	
Bulgaria	310	300	
Canada	1,800	1,700	
China	9,300	9,300	
Germany	—	170	
Japan	1,800	1,700	
Kazakhstan	1,000	1,000	
Korea, Republic of	4,500	4,500	
Mexico	[10]1,020	1,200	
Netherlands	[10]726	400	
Norway	420	350	
Peru	[10]494	620	
Poland	250	250	
Russia	1,000	800	
Uzbekistan	220	200	
World total (rounded)	24,100	24,000	

World Resources:[9] Cadmium is generally recovered from zinc ores and concentrates. Sphalerite, the most economically significant zinc ore mineral, commonly contains minor amounts of cadmium, which shares certain similar chemical properties with zinc and often substitutes for zinc in the sphalerite crystal lattice. The cadmium mineral greenockite is frequently associated with weathered sphalerite and wurtzite.

Substitutes: Batteries with other chemistries, particularly lithium-ion, can replace NiCd batteries in many applications. Except where the surface characteristics of a coating are critical (for example, fasteners for aircraft), coatings such as zinc-nickel can be substituted for cadmium in many plating applications. Cerium sulfide is used as a replacement for cadmium pigments, mostly in plastics. Barium stabilizers can replace barium-cadmium stabilizers in flexible polyvinyl chloride (PVC) applications. Thin-film technologies based on copper-indium-gallium-selenide and perovskite materials continued to be investigated but were not yet commercially feasible.

[e]Estimated. E Net exporter. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Cadmium metal produced as a byproduct of zinc refining.
[2]Less than ½ unit.
[3]Defined as primary production + secondary production + imports of unwrought cadmium and powders – exports of unwrought cadmium and powders.
[4]Average free market price for 99.95% purity in 10-ton lots; cost, insurance, and freight; global ports. Source: Fastmarkets MB.
[5]Defined as imports of unwrought cadmium and powders – exports of unwrought cadmium and powders.
[6]Unwrought cadmium and powders; Harmonized Tariff Schedule of the United States code 8107.20.0000 for 2019–21 and 8112.69.1000 beginning in 2022.
[7]Includes Hong Kong.
[8]See Appendix B for definitions.
[9]See Appendix C for resource and reserve definitions and information concerning data sources.
[10]Reported.

CEMENT

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: In 2024, U.S. portland and blended cement production decreased by 4% to an estimated 84 million tons, and masonry cement production also decreased by 4% to an estimated 2.2 million tons. Cement was produced at 99 plants in 34 States and in Puerto Rico. Texas, Missouri, California, and Florida were, in descending order of production, the four leading cement-producing States and accounted for approximately 43% of U.S. production. Overall, the U.S. cement industry's growth continued to be constrained by closed or idle plants, underutilized capacity at others, production disruptions from plant upgrades, and relatively inexpensive imports. In 2024, shipments of cement were an estimated 110 million tons with an estimated value of $17 billion. In 2024, an estimated 70% to 75% of sales were to ready-mixed concrete producers, 12% to concrete product manufacturers, 8% to 10% to contractors, and 5% to 10% to other customer types.

Salient Statistics—United States:[1]	2020	2021	2022	2023	2024[e]
Production:					
Portland and masonry cement[2]	89,300	91,000	91,200	[e]90,000	86,000
Clinker	78,951	79,616	79,489	[e]77,000	73,000
Shipments to final customers, includes exports	104,580	108,969	111,092	[e]110,000	110,000
Imports for consumption:					
Hydraulic cement	15,531	19,937	24,985	24,986	24,000
Clinker	1,204	1,563	1,021	921	820
Exports, hydraulic cement and clinker	884	939	904	889	900
Consumption, apparent[3]	105,000	111,000	114,000	[e]110,000	110,000
Price, average mill unit value, dollars per metric ton	125	127	139	[e]150	160
Stocks, cement, yearend	7,180	6,280	8,020	[e]8,500	7,500
Employment, mine and mill, number[e]	12,200	12,300	12,800	13,000	13,000
Net import reliance[4] as a percentage of apparent consumption	15	19	22	22	22

Recycling: Cement is not recycled, but significant quantities of concrete are recycled for use as a construction aggregate. Cement kilns can use waste fuels, recycled cement kiln dust, and recycled raw materials such as slags and fly ash. Various secondary materials can be incorporated as supplementary cementitious materials (SCMs) in blended cements and in the cement paste in concrete.

Import Sources (2020–23):[5] Turkey, 32%; Canada, 22%; Vietnam, 10%; Greece, 9%; and other, 27%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Cement clinker	2523.10.0000	Free.
White portland cement	2523.21.0000	Free.
Other portland cement	2523.29.0000	Free.
Aluminous cement	2523.30.0000	Free.
Other hydraulic cement	2523.90.0000	Free.

Depletion Allowance: Not applicable. Certain raw materials for cement production have depletion allowances.

Government Stockpile: None.

Events, Trends, and Issues: The value of total construction put in place in the United States increased by 7% during the first 9 months of 2024 compared with that in the same period in 2023. Both residential and nonresidential construction spending increased; however, new privately owned housing units started through September 2024 decreased by 3% compared with those during the same period in 2023. Reported cement shipments decreased by 6% during the first 8 months of 2024 compared with those in the same period in 2023. The leading cement-consuming States continued to be Texas, Florida, and California, in descending order by tonnage.

According to the Bureau of Economic Analysis, the real gross domestic product (GDP) increased by 5% during the first 9 months of 2024 compared with the real GDP for full year 2023. The Federal Reserve lowered interest rates in 2024, and funding from the Bipartisan Infrastructure Law and the Inflation Reduction Act continued to be allocated to projects moving forward in each State expected to rebuild and modernize infrastructure and strengthen supply chains. Government funds were also awarded to support sustainability, and several cement producers were selected for decarbonization initiatives. Regulators continued to implement clean public procurement strategies and announce research investments. Apparent consumption of cement in 2024 was estimated to be unchanged from that in 2023.

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CEMENT

Company merger-and-acquisition activity in 2024 included the acquisition of a United States-based company's cement plant in Texas by an Ireland-based company and the completed merger of a Colombia-based cement company and a United States-based cement company. In November, a United States-based concrete and cement company reached an agreement to acquire a United States-based cement company, and a Germany-based cement company announced an agreement to acquire another United States-based cement company—each transaction was pending regulatory approval. Plans to increase clinker capacity at a cement plant in Texas and plans to expand a cement plant in Missouri progressed. In May 2024, plans to modernize and expand a cement plant in Wyoming were announced. A cement plant in Indiana was repurposed into a slag-grinding facility in June, and construction of a new slag cement facility in Texas continued. Several minor upgrades were ongoing at some other domestic plants and terminals. Announcements aligned with sustainability included the increased or enhanced use of alternative fuels and materials, carbon capture, utilization and storage projects, improved efficiency, renewable energy, and other innovations. Development of novel cement product lines progressed; two pilot plant cement facilities were planned.

In April 2024, the Connecticut Department of Transportation approved the use of portland-limestone cement (PLC), signifying its adoption by all 50 States and the District of Columbia. Blended cement accounted for 58% of total cement shipments during the first 8 months of 2024, and 97% of the blended shipments were estimated to be PLC (Type IL). In February 2024, the U.S. Environmental Protection Agency issued its "Final Reconsideration of the National Ambient Air Quality Standards for Particulate Matter (PM)"; in March 2024, a coalition of associations expressed concern regarding the lower emissions standard for PM ≤2.5 micrometers in diameter. Many plants have installed emissions-reduction equipment to comply with the 2010 National Emissions Standards for Hazardous Air Pollutants (NESHAP). Some kilns could be shut, idled, or used at reduced capacity to comply with regulations, which would constrain U.S. clinker capacity. In 2022 and 2023, cement plant closures were announced in California, Maine, and New York; in 2024, the plant in Maine transitioned to a distribution center for imported material. Also in 2024, a termination notice was issued to a cement plant in Colorado, and its operational status remained under review by the county.

World Production and Capacity:

	Cement production[e]		Clinker capacity[e]	
	2023	2024	2023	2024
United States (includes Puerto Rico)	90,000	86,000	100,000	100,000
Brazil	67,000	68,000	60,000	60,000
China	2,000,000	1,900,000	2,000,000	1,900,000
Egypt	52,000	50,000	60,000	60,000
India	420,000	450,000	300,000	380,000
Indonesia	67,000	65,000	79,000	79,000
Iran	71,000	72,000	81,000	85,000
Japan	48,000	46,000	54,000	50,000
Korea, Republic of	51,000	52,000	62,000	62,000
Mexico	48,000	48,000	42,000	42,000
Russia	63,000	65,000	80,000	80,000
Saudi Arabia	49,000	50,000	75,000	75,000
Turkey	81,000	82,000	92,000	92,000
Vietnam	110,000	110,000	110,000	110,000
Other countries (rounded)	850,000	860,000	600,000	650,000
World total (rounded)	4,100,000	4,000,000	3,800,000	3,800,000

World Resources: See the Lime and Stone (Crushed) chapters for cement raw-material resources.

Substitutes: Most portland cement is used to make concrete, mortars, or stuccos, and competes in the construction sector with concrete substitutes, such as aluminum, asphalt, clay brick, fiberglass, glass, gypsum (plaster), steel, stone, and wood. Certain materials, especially fly ash and ground granulated blast furnace slag, develop good hydraulic cementitious properties by reacting with lime, such as that released by the hydration of portland cement. Where readily available (including as imports), these SCMs are increasingly being used as partial substitutes for portland cement in many concrete applications and are components of finished blended cements.

[e]Estimated.

[1]Portland cement plus masonry cement unless otherwise specified; excludes Puerto Rico unless otherwise specified.

[2]Includes cement made from imported clinker.

[3]Defined as production of cement (including from imported clinker) + imports (excluding clinker) – exports ± adjustments for stock changes.

[4]Defined as imports (cement and clinker) – exports.

[5]Hydraulic cement and clinker; includes imports into Puerto Rico.

CESIUM

(Data in metric tons, cesium oxide, unless otherwise specified)

Domestic Production and Use: In 2024, no cesium was mined domestically, and the United States was 100% net import reliant for cesium minerals. Pollucite, mainly found in association with lithium-rich, lepidolite-bearing or petalite-bearing zoned granite pegmatites, is the principal cesium ore mineral. Cesium minerals are used as feedstocks to produce a variety of cesium compounds and cesium metal. The primary application for cesium, by gross weight, is in cesium formate brines used for high-pressure, high-temperature well drilling for oil and gas exploration and production. With the exception of cesium formate, cesium is used in relatively small-scale applications, using only a few grams for most applications. Owing to the lack of global availability of cesium, many applications have used mineral substitutes and the use of cesium in any particular application may no longer be viable.

Cesium metal may be used in the production of cesium compounds and photoelectric cells. Cesium bromide may be used in infrared detectors, optics, photoelectric cells, scintillation counters, and spectrophotometers. Cesium carbonate may be used in the alkylation of organic compounds and in energy conversion devices, such as fuel cells, magneto-hydrodynamic generators, and polymer solar cells. Cesium chloride may be used in analytical chemistry applications as a reagent, in high-temperature solders, as an intermediate in cesium metal production, in isopycnic centrifugation, as a radioisotope in nuclear medicine, as an insect repellent in agricultural applications, and in specialty glasses. Cesium hydroxide may be used as an electrolyte in alkaline storage batteries. Cesium iodide may be used in fluoroscopy equipment—Fourier-transform infrared spectrometers—as the input phosphor of X-ray image intensifier tubes, and in scintillators. Cesium nitrate may be used as a colorant and oxidizer in the pyrotechnic industry, in petroleum cracking, in scintillation counters, and in X-ray phosphors. Cesium sulfates may be used in water treatment, fuel cells, and to improve optical quality for scientific instruments.

For industrial uses, cesium catalysts have largely replaced potassium promoters in high-purity sulfuric acid manufacturing, which may enable lower plant stack emissions and lower ignition temperatures. Additionally, cesium catalysts are primarily used in methyl methacrylate manufacturing in place of conventional cyanide-based processes and are necessary to improve efficiency, lower operating costs, and reduce environmental impacts. Sulfuric acid catalysts and methyl methacrylate may be used in aerospace, automotive, and manufacturing applications.

Cesium isotopes, which are obtained as a byproduct in nuclear fission or formed from other isotopes, such as barium-131, may be used in electronic, medical, metallurgical, and research applications. Cesium isotopes are used as an atomic resonance frequency standard in atomic clocks, playing a vital role in aircraft guidance systems, global positioning satellites, and internet and cellular telephone transmissions.

A company in Richland, WA, produced a range of cesium-131 medical products for treatment of various cancers. Cesium-137 may be used in industrial gauges, in mining and geophysical instruments, and for sterilization of food, sewage, and surgical equipment. Because of the danger posed by the radiological properties of cesium-137, Congress set a goal for the National Nuclear Security Administration to eliminate cesium-137 blood irradiators by 2027 in the United States. Alternatives, including X-ray irradiators, have been developed with similar capabilities and have been partially implemented with subsidization.

Salient Statistics—United States: Consumption, import, and export data for cesium have not been available since the late 1980s. Because cesium metal is not traded in commercial quantities, a market price is unavailable. It is estimated that no more than a few thousand kilograms of cesium chemicals are consumed in the United States every year. The United States was 100% net import reliant for its cesium needs, and the primary global producers were estimated to include Canada, China, Germany, and Russia.

In 2024, one company offered 1-gram ampoules of 99.8% (metal basis) cesium for $98.00, a 7% increase from $91.60 in 2023, and 99.98% (metal basis) cesium for $124, a 6% increase from $117 in 2023. At the end of September 2024, the prices for 50 grams of 99.9% (metal basis) cesium acetate, cesium bromide, cesium carbonate, cesium chloride, and cesium iodide were $150.60, $104.00, $135.40, $152.00, and $173.60, respectively, with increases ranging from 5% to 6% compared with prices in 2023.

The price for a cesium-plasma standard solution (10,000 micrograms per milliliter) in 2024 was $93.40 for 50 milliliters and $142.00 for 100 milliliters, increases of 4% from $89.80 and $137.00 in 2023, respectively. The price for 25 grams of 98% (metal basis) cesium formate was $52.40, a 6% increase from $49.40 in 2023.

Recycling: Cesium formate brines are typically rented by oil and gas exploration clients. After completion of the well, the used cesium formate brine is returned and reprocessed for subsequent drilling operations. Cesium formate brines are recycled, recovering nearly 85% of the brines for recycling to be reprocessed for further use.

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CESIUM

Import Sources (2020–23): No reliable data have been available to determine the source of cesium ore imported by the United States since 1988. Prior to 2016, Canada was estimated to be the primary supplier of cesium ore and refined chemicals. Based on recent import data, it was estimated that China and Germany were sources of cesium chemicals.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Alkali metals, other	2805.19.9000	5.5% ad valorem.
Chlorides, other	2827.39.9000	3.7% ad valorem.
Bromides, other	2827.59.5100	3.6% ad valorem.
Iodides, other	2827.60.5100	4.2% ad valorem.
Sulfates, other	2833.29.5100	3.7% ad valorem.
Nitrates, other	2834.29.5100	3.5% ad valorem.
Carbonates, other	2836.99.5000	3.7% ad valorem.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic cesium occurrences will likely remain subeconomic unless market conditions change. No known human health issues are associated with exposure to naturally occurring cesium, and its use has minimal environmental impacts. Manufactured radioactive isotopes of cesium have been known to cause adverse health effects. Certain cesium compounds may be toxic if consumed. Food that has been irradiated using the radioisotope cesium-137 has been found to be safe by the U.S. Food and Drug Administration.

During 2024, one company in Canada reported intermittent cesium production and processing from mined ore and stockpiles at the Tanco Mine. Cesium ore also was estimated to have been mined in China. All other primary mine production of cesium was believed to have ceased within the past two decades. Mining of cesium in Namibia ceased in the early 2000s. The Bikita Mine in Zimbabwe was depleted of pollucite ore reserves in 2018. The Sinclair Mine in Australia completed the mining and shipments of all economically recoverable pollucite ore in 2019.

Throughout 2024, multiple projects that could produce cesium through lepidolite, pollucite, spodumene, and zinnwaldite mining, focused primarily on lithium or cesium extraction, were in the feasibility and exploration stage. One company continued developing a lepidolite concentration mine and processing facility in Namibia, with a targeted lithium hydroxide capacity of 5,700 tons per year expected to commence operations in 2026. Byproduct cesium production was expected to be sent to a downstream chemical conversion facility in Abu Dhabi.

World Mine Production and Reserves:[1] There were no official sources for cesium production data in 2024. Cesium reserves are, therefore, estimated based on the occurrence of pollucite, a primary cesium mineral. Most pollucite contains 5% to 32% cesium oxide. No reliable data were available to determine reserves for specific countries; however, Australia, Canada, China, and Namibia were estimated to have reserves totaling less than 200,000 tons. Existing stockpiles at multiple former mine sites have continued feeding downstream refineries, though recent reports have indicated that stockpiles may be depleted within a few years. The global market of cesium chemical products, excluding cesium formate, was estimated to be 2,200 tons per year. China was estimated to account for 1,000 tons per year of that market. An estimated 11,000 tons of cesium formate were in use, with 5% being depleted and replaced annually.

World Resources:[1] Cesium is associated with lithium-bearing pegmatites worldwide, and cesium resources have been identified in Australia, Canada, Namibia, the United States, and Zimbabwe. In the United States, pollucite occurs in pegmatites in Alaska, Maine, and South Dakota. Lower concentrations occur in brines in Chile and China and in geothermal systems in China, Germany, and India. China was estimated to have cesium-rich deposits of geyserite, lepidolite, and pollucite, with concentrations highest in Yichun, Jiangxi Province, although no resource, reserve, or production estimates were available.

Substitutes: Cesium and rubidium can be used interchangeably in many applications because they have similar physical properties and atomic radii. Cesium, however, is more electropositive than rubidium, making it a preferred material for some applications. However, rubidium is mined from similar deposits, in relatively smaller quantities, as a byproduct of cesium production in pegmatites and as a byproduct of lithium production from lepidolite (hard-rock) mining and processing, making it no more readily available than cesium.

[1]See Appendix C for resource and reserve definitions and information concerning data sources.

CHROMIUM

(Data in thousand metric tons, chromium content, unless otherwise specified)

Domestic Production and Use: In 2024, the United States consumed an estimated 4% of world chromite ore production in various forms of imported materials, such as chromite ore, chromium chemicals, ferrochromium, chromium metal, and stainless steel. Imported chromite ore was consumed by one chemical company to produce chromium chemicals. Stainless-steel and heat-resisting-steel producers were the leading consumers of ferrochromium. Stainless steels and superalloys require the addition of chromium via ferrochromium or chromium-containing scrap. The value of chromium material consumption was estimated to be $900 million in 2024 (as measured by the value of net imports, excluding stainless steel), which was a 6% increase from $846 million in 2023.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Mine	—	—	—	—	—
Secondary[1]	119	114	91	126	100
Imports for consumption[2]	448	571	610	451	500
Exports[2]	138	114	132	148	160
Shipments from Government stockpile[3]	5	7	5	NA	NA
Consumption (includes recycling):					
Reported	387	364	275	[e]290	300
Apparent[4]	433	579	574	429	440
Price:[5]					
Chromite ore (gross weight), dollars per metric ton	158	199	277	321	340
Ferrochromium (chromium content), dollars per pound[6]	0.89	1.50	3.19	2.55	1.80
Chromium metal (gross weight), dollars per pound	3.10	4.23	7.20	5.05	5.60
Stocks, consumer, yearend	6	6	5	[e]5	5
Net import reliance[7] as a percentage of apparent consumption	73	80	84	71	77

Recycling: In 2024, recycled chromium (contained in reported stainless-steel scrap receipts) accounted for 23% of apparent consumption.

Import Sources (2020–23): Chromite (ores and concentrates): South Africa, 96%; Turkey, 3%; and other, 1%.
Chromium-containing scrap:[8] Canada, 51%; Mexico, 43%; and other, 6%.
Chromium (primary metal):[9] South Africa, 25%; Kazakhstan, 14%; Finland, 7%; Russia, 6%; and other, 48%.
Chromium-containing chemicals: Kazakhstan, 24%; China,[10] 18%; Germany, 17%; Italy, 12%; and other, 29%.
Total imports: South Africa, 32%; Kazakhstan, 11%; Canada, 6%; Finland, 6%; and other, 45%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Chromium ores and concentrates:		
Not more than 40% chromic oxide (Cr_2O_3)	2610.00.0020	Free.
More than 40% but less than 46% Cr_2O_3	2610.00.0040	Free.
More than or equal to 46% Cr_2O_3	2610.00.0060	Free.
Ferrochromium:		
More than 4% carbon	7202.41.0000	1.9% ad valorem.
More than 3% but less than 4% carbon	7202.49.1000	1.9% ad valorem.
More than 0.5% but less than 3% carbon	7202.49.5010	3.1% ad valorem.
Not more than 0.5% carbon	7202.49.5090	3.1% ad valorem.
Ferrosilicon chromium	7202.50.0000	10% ad valorem.
Stainless-steel scrap	7204.21.0000	Free.
Chromium metal:		
Unwrought, powder	8112.21.0000	3% ad valorem.
Waste and scrap	8112.22.0000	Free.
Other	8112.29.0000	3% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

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CHROMIUM

Government Stockpile (gross weight):[11]

	FY 2024		FY 2025	
Material	**Potential acquisitions**	**Potential disposals**	**Potential acquisitions**	**Potential disposals**
Ferrochromium[12]	—	21.8	—	21.8
Chromium metal	—	0.454	—	0.454

Events, Trends, and Issues: South Africa was the leading chromite ore producer. Global chromite ore mine production was estimated to have increased by 4 in% 2024 compared with production in 2023. Production in South Africa, the world's leading producer of chromite, increased by an estimated 7% compared with production in 2023, largely owing to an increase in the average price of chromite ore. However, challenges related to deep-level mining, increased labor costs, ongoing issues with rail transportation, and an unreliable supply of electricity could affect production in South Africa.

China was the leading ferrochromium- and stainless-steel-producing country and the leading chromium-consuming country. However, the production of stainless steel in China has been affected by oversupply, decreases in consumer demand, and escalating trade tensions, which have led to decreases in the price of ferrochromium.

World Mine Production (gross weight) and Reserves: Reserves for Kazakhstan were revised based on a Government report.

	Mine production (marketable)		Reserves[13] (shipping grade)[14]
	2023	**2024[e]**	
United States	—	—	630
Brazil	1,420	1,400	6,600
Finland	1,910	1,900	8,300
India[e]	4,100	4,100	79,000
Kazakhstan[e]	6,000	6,500	320,000
South Africa	19,700	21,000	200,000
Turkey	8,160	8,000	27,000
Zimbabwe	1,070	1,100	540,000
Other countries	2,880	2,900	NA
World total (rounded)	45,200	47,000	>1,200,000

World Resources:[13] World resources are greater than 12 billion tons of shipping-grade chromite, sufficient to meet conceivable demand for centuries. World chromium resources are heavily geographically concentrated (95%) in Kazakhstan and southern Africa; United States chromium resources are mostly in the Stillwater Complex in Montana.

Substitutes: Chromium has no substitute in stainless steel, the leading end use, or in superalloys, the major strategic end use. Chromium-containing scrap can substitute for ferrochromium in some metallurgical uses.

[e]Estimated. NA Not available. — Zero.
[1]Secondary production is based on reported receipts of all types of stainless-steel scrap.
[2]Includes chromium chemicals, chromium metal, chromite ores, ferrochromium, ferrosilicon chromium, and stainless-steel products and scrap.
[3]Defined as change in total inventory from prior yearend inventory. Beginning in 2023, Government stock changes no longer available.
[4]Defined for 2020–22 as production (from mines and secondary) + imports – exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.
[5]Source: Argus Media Group, Argus Non-Ferrous Markets.
[6]Excludes ferrosilicon chromium.
[7]Defined for 2020–22 as imports – exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.
[8]Includes chromium metal scrap and stainless-steel scrap.
[9]Includes chromium metal, ferrochromium, and stainless steel.
[10]Includes Hong Kong.
[11]See Appendix B for definitions.
[12]High-carbon and low-carbon ferrochromium, combined.
[13]See Appendix C for resource and reserve definitions and information concerning data sources.
[14]Units are thousand metric tons gross weight of shipping-grade chromite ore, which is deposit quantity and grade normalized to 45% Cr_2O_3, except for the United States, where grade is normalized to 7% Cr_2O_3, and Finland, where grade is normalized to 26% Cr_2O_3.

CLAYS

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: Production of clays (sold or used) in the United States was estimated to be 26 million tons valued at $1.7 billion in 2024, with about 120 companies operating clay and shale mines in 38 States. The leading 20 companies produced approximately 66% of the U.S. tonnage and 82% of the value for all types of clay. Principal domestic uses for specific clays were estimated to be as follows: ball clay (61% floor and wall tile), bentonite (48% pet waste absorbents and 23% drilling mud), common clay (47% brick, 25% lightweight aggregate, and 22% cement), fuller's earth (77% absorbents, including oil and grease absorbents, pet waste absorbents, and miscellaneous absorbents), and kaolin (54% fillers, extenders, and binders and 23% ceramics). Fire clay uses were withheld to avoid disclosing company proprietary data.

In 2024, the United States exported an estimated 700,000 tons of bentonite; Canada, Japan, and Mexico, in decreasing order, were the leading destinations. About 1.6 million tons of kaolin was exported mainly as a paper coating and filler; a component in ceramic bodies; and fillers and extenders in paint, plastic, and rubber products; China, Mexico, and Japan, in decreasing order, were the leading destinations. Lesser quantities of ball clay, fire clay, and fuller's earth were exported.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production (sold or used):					
Ball clay	985	[e]1,080	[e]1,030	[e]1,000	1,000
Bentonite	4,250	4,580	4,580	4,360	4,800
Common clay	12,900	12,700	12,900	12,500	13,000
Fire clay	635	675	[e]622	685	670
Fuller's earth[e, 1]	2,120	2,240	2,200	2,260	2,400
Kaolin[e]	4,640	4,360	4,340	4,560	4,500
Total[1, 2]	25,500	25,700	25,700	25,400	26,000
Imports for consumption:					
Artificially activated clays and earths	31	41	58	72	66
Kaolin	224	149	200	125	130
Other	28	47	49	35	66
Total[2]	284	237	306	232	270
Exports:					
Artificially activated clays and earths	127	139	134	92	92
Ball clay	68	139	165	145	170
Bentonite	728	861	830	785	700
Clays, not elsewhere classified	185	186	208	194	180
Fire clay[3]	190	210	158	133	140
Fuller's earth	77	83	87	70	75
Kaolin	1,990	2,330	2,020	1,510	1,600
Total[2]	3,360	3,950	3,610	2,930	2,900
Consumption, apparent[4]	22,400	22,000	22,400	22,700	23,000
Price, average unit value, ex-works, dollars per metric ton:					
Ball clay	46	46	47	44	44
Bentonite	97	100	101	102	99
Common clay	17	17	17	18	18
Fire clay	12	12	12	15	15
Fuller's earth[1]	90	88	91	91	90
Kaolin	159	152	157	161	160
Employment (excludes office workers), number:[e]					
Mine (may not include contract workers)	1,060	1,060	1,060	1,110	1,200
Mill	4,260	4,240	4,240	4,320	4,400
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2020–23): All clay types combined: Brazil, 62%; Mexico, 21%; China, 3%; Spain 3%; and other, 11%.

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CLAYS

Tariff: Item	Number	Normal Trade Relations 12–31–24
Kaolin and other kaolinic clays, whether or not calcined	2507.00.0000	Free.
Bentonite	2508.10.0000	Free.
Fire clay	2508.30.0000	Free.
Common blue clay and other ball clays	2508.40.0110	Free.
Decolorizing earths and fuller's earth	2508.40.0120	Free.
Other clays	2508.40.0150	Free.
Chamotte or dinas earth	2508.70.0000	Free.
Activated clays and activated earths	3802.90.2000	2.5% ad valorem.
Expanded clays and other mixtures	6806.20.0000	Free.

Depletion Allowance: Ball clay, bentonite, fire clay, fuller's earth, and kaolin, 14% (domestic and foreign); clay used in the manufacture of common brick, lightweight aggregate, and sewer pipe, 7.5% (domestic and foreign); clay used in the manufacture of drain and roofing tile, flowerpots, and kindred products, 5% (domestic and foreign); clay from which alumina and aluminum compounds are extracted, 22% (domestic).

Government Stockpile: None.

Events, Trends, and Issues: The total tonnage of clays sold or used by domestic producers increased from that in 2023; ball clay, bentonite, common clay, and fuller's earth, increased or were unchanged, whereas fire clay and kaolin decreased in 2024. Imports for all types of clay increased by 14% to 270,000 tons; Brazil and Mexico, in decreasing order, were the major sources for imported clays in 2024. U.S. apparent consumption in 2024 was estimated to be 23 million tons, compared with 22.7 million tons in 2023.

World Mine Production and Reserves:[6] Global reserves are large, but country-specific data were not available.

	Mine production					
	Bentonite		Fuller's earth		Kaolin	
	2023	2024[e]	2023	2024[e]	2023	2024[e]
United States	4,360	4,800	[1]2,260	[1]2,400	[e]4,560	4,500
Brazil (beneficiated)	386	390	—	—	828	830
China	[e]2,100	2,100	—	—	[e]7,800	7,800
Czechia	196	200	—	—	[7]2,400	[7]2,400
Denmark	[e]925	930	—	—	—	—
Greece	[7]1,110	[7]1,100	49	50	—	—
India	[e]3,700	3,700	[e]730	730	[e, 7]8,400	[7]8,400
Iran	[e]850	850	—	—	[e]2,100	2,100
Mexico	[e]79	80	[e]120	120	[e]230	230
Russia	[e]36	40	—	—	[e]2,500	2,500
Senegal	—	—	[e]150	150	—	—
Spain	118	120	[e]620	620	[e, 7]280	[7]280
Turkey	2,490	2,500	74	70	1,350	1,300
Uzbekistan	[e]60	60	—	—	[e]4,000	4,000
Other countries	3,870	3,900	195	190	9,950	9,900
World total (rounded)[2]	20,300	21,000	[1]4,200	[1]4,300	44,400	44,000

World Resources:[6] Resources of all clays are extremely large.

Substitutes: Clays compete with calcium carbonate in filler and extender applications; diatomite, organic pet litters, polymers, silica gel, and zeolites as absorbents; and various siding and roofing types in building construction.

[e]Estimated. E Net exporter. — Zero.
[1]Does not include U.S. production of attapulgite.
[2]Data may not add to totals shown because of independent rounding.
[3]Includes refractory-grade kaolin.
[4]Defined as production (sold or used) + imports – exports.
[5]Defined as imports – exports.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]Includes production of crude ore.

COBALT

(Data in metric tons, cobalt content, unless otherwise specified)

Domestic Production and Use: In 2024, the Eagle Mine, a nickel-copper mine in Michigan, produced cobalt-bearing nickel concentrate, which was exported to Canada or overseas for processing. Mining activity at a cobalt-copper-gold mine in Idaho remained suspended in 2024 owing to low cobalt prices. Most U.S. cobalt supply consisted of imports and secondary (scrap) materials. About five companies in the United States produced cobalt chemicals. An estimated 51% of cobalt consumed in the United States was used in superalloys, mainly aircraft gas turbine engines; 25% in a variety of chemical applications; 15% in various other metallic applications; and 9% in cemented carbides for cutting and wear-resistant applications. The total estimated value of cobalt consumed in 2024 was $260 million.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:[e]					
Mine	600	650	500	500	300
Secondary[1]	2,010	1,800	1,920	2,030	2,000
Imports for consumption	9,740	9,790	10,500	9,500	11,000
Exports	3,430	4,930	5,360	5,110	4,500
Consumption (includes secondary):					
Estimated[2]	7,260	7,270	7,570	7,840	8,000
Apparent[e, 3]	8,480	6,650	7,150	6,440	8,500
Price, average, dollars per pound:					
U.S. spot, cathode[4]	15.70	24.21	30.78	17.20	17
London Metal Exchange (LME), cash	14.21	23.17	28.83	15.48	12
Stocks, yearend:					
Industry[e, 2, 5]	952	1,010	946	925	900
LME, U.S. warehouse	82	50	34	34	34
Net import reliance[6] as a percentage of apparent consumption	76	73	73	69	76

Recycling: In 2024, cobalt content of purchased scrap represented 25% of estimated cobalt consumption.

Import Sources (2020–23): Metal, oxide, and salts: Norway, 27%; Finland, 17%; Japan, 14%; Canada, 13%; and other, 29%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Cobalt ores and concentrates	2605.00.0000	Free.
Chemical compounds:		
Cobalt oxides and hydroxides	2822.00.0000	0.1% ad valorem.
Cobalt chlorides	2827.39.6000	4.2% ad valorem.
Cobalt sulfates	2833.29.1000	1.4% ad valorem.
Cobalt carbonates	2836.99.1000	4.2% ad valorem.
Cobalt acetates	2915.29.3000	4.2% ad valorem.
Unwrought cobalt, alloys	8105.20.3000	4.4% ad valorem.
Unwrought cobalt, other	8105.20.6000	Free.
Cobalt mattes and other intermediate products; cobalt powders	8105.20.9000	Free.
Cobalt waste and scrap	8105.30.0000	Free.
Wrought cobalt and cobalt articles	8105.90.0000	3.7% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile:[7]

	FY 2024		FY 2025	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Cobalt alloys, gross weight[8]	200	—	60	—

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COBALT

Events, Trends, and Issues: Global cobalt mine and refinery production were estimated to have increased to another record high in 2024. The increase in mine production was mainly in Congo (Kinshasa), the world's leading source of mined cobalt, which accounted for an estimated 76% of world cobalt mine production, followed by Indonesia, which accounted for 10%. China was the world's leading producer of refined cobalt and increased metal refining capacity throughout the year. The majority of China's refinery production was from partially refined cobalt imported from Congo (Kinshasa) and Indonesia. China was the world's leading consumer of cobalt, with the majority used by the lithium-ion battery industry. New production of mined and refined cobalt has led to excess global supply and lower cobalt prices. In 2024, the United States enacted tariff rate increases on cobalt ores and concentrates originating from China, as well as cobalt-containing products including electric vehicles and lithium-ion batteries.

World Mine Production and Reserves: Reserves for the United States, Canada, Indonesia, Papua New Guinea, and "Other countries" were revised based on company and Government reports.

	Mine production[e]		Reserves[9]
	2023	2024	
United States	500	300	70,000
Australia	5,220	3,600	[10]1,700,000
Canada	4,220	4,500	220,000
Congo (Kinshasa)	175,000	220,000	6,000,000
Cuba	3,300	3,500	500,000
Indonesia	19,000	28,000	640,000
Madagascar	4,000	2,600	100,000
New Caledonia[11]	2,570	1,500	NA
Papua New Guinea	3,070	2,800	62,000
Philippines	3,800	3,800	260,000
Russia	8,700	8,700	250,000
Turkey	2,500	2,700	91,000
Other countries	6,080	6,200	800,000
World total (rounded)	238,000	290,000	11,000,000

World Resources:[9] Identified cobalt resources of the United States are estimated to be about 1 million tons. Most of these resources are in Minnesota. Other notable occurrences are in Alaska, California, Idaho, Michigan, Missouri, Montana, Oregon, and Pennsylvania. Identified world terrestrial cobalt resources are about 25 million tons. The vast majority of global resources are in sediment-hosted stratiform copper deposits in Congo (Kinshasa) and Zambia; nickel-bearing laterite deposits in Australia and nearby island countries and Cuba; and magmatic nickel-copper sulfide deposits of mafic and ultramafic rocks in Australia, Canada, Russia, and the United States.

Substitutes: Depending on the application, substitution for cobalt could result in a loss in product performance or increase cost. The cobalt contents of lithium-ion batteries, the leading global use for cobalt, are being reduced; cobalt-free substitutes that use iron and phosphorus held significant market share in China. Potential substitutes in other applications include barium or strontium ferrites, neodymium-iron-boron alloys, or nickel-iron alloys in magnets; cerium, iron, lead, manganese, or vanadium in paints; cobalt-iron-copper or iron-copper in diamond tools; copper-iron-manganese for curing unsaturated polyester resins; iron, iron-cobalt-nickel, nickel, ceramic-metallic composites (cermets), or ceramics in cutting and wear-resistant materials; nickel-base alloys or ceramics in jet engines; nickel in petroleum catalysts; rhodium in hydroformylation catalysts; and titanium-base alloys in prosthetics.

[e]Estimated, — Zero. NA Not available.
[1]Estimated from consumption of purchased scrap.
[2]Includes reported data and U.S. Geological Survey estimates.
[3]Defined for 2020–22 as secondary production + imports – exports ± adjustments for Government and industry stock changes for refined cobalt. Beginning in 2023, Government stock changes no longer included.
[4]Source: S&P Global Platts Metals Week. Cobalt cathode is refined cobalt metal produced by an electrolytic process.
[5]Stocks held by consumers and processors; excludes stocks held by trading companies and held for investment purposes.
[6]Defined for 2020–22 as imports – exports ± adjustments for Government and industry stock changes for refined cobalt. Beginning in 2023, Government stock changes no longer included.
[7]See Appendix B for definitions.
[8]Samarium-cobalt alloy; excludes potential disposals of aerospace alloys.
[9]See Appendix C for resource and reserve definitions and information concerning data sources.
[10]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 610,000 tons.
[11]Overseas territory of France.

COPPER

(Data in thousand metric tons, copper content, unless otherwise specified)

Domestic Production and Use: In 2024, the recoverable copper content of U.S. mine production was an estimated 1.1 million tons, a decrease of 3% from that in 2023, and was valued at an estimated $10 billion, slightly greater than $9.83 billion in 2023. Arizona was the leading copper-producing State and accounted for approximately 70% of domestic output; copper was also mined in Michigan, Missouri, Montana, Nevada, New Mexico, and Utah. Copper was recovered or processed at 25 mines (17 of which accounted for more than 99% of mine production), 2 primary smelters, 1 secondary smelter, 2 primary electrolytic refineries, 14 electrowon refineries, and 3 secondary fire refineries. A new secondary smelter and secondary refinery were expected to start up by yearend. Refined copper and scrap were consumed at about 30 brass mills, 14 rod mills, and several hundred foundries and miscellaneous manufacturers. According to the Copper Development Association, copper and copper alloy products were used in building construction, 42%; electrical and electronic products, 23%; transportation equipment, 18%; consumer and general products, 10%; and industrial machinery and equipment, 7%.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Mine, recoverable	1,200	1,230	1,230	1,130	1,100
Refinery:					
Primary (from ore)	872	922	930	843	850
Secondary (from scrap)	43	49	40	39	40
Copper recovered from old (post-consumer) scrap[1]	161	169	152	[e]150	150
Imports for consumption:					
Ore and concentrates	2	11	12	3	([2])
Refined	676	919	732	771	810
Exports:					
Ore and concentrates	383	344	351	339	320
Refined	41	48	27	33	60
Consumption:					
Reported, refined copper	1,680	1,750	1,720	1,570	1,600
Apparent, primary refined copper and copper from old scrap[3]	1,660	1,960	1,820	1,690	1,800
Price, annual average, cents per pound:					
U.S. producer, cathode (COMEX + premium)	286.7	432.3	410.8	395.3	430
COMEX, high-grade, first position	279.9	424.3	400.7	385.7	420
London Metal Exchange, grade A, cash	279.8	422.5	399.8	384.8	420
Stocks, refined, held by U.S. producers, consumers, and metal exchanges, yearend	118	117	84	127	70
Employment, mine and plant, number	11,000	11,400	12,000	12,600	13,000
Net import reliance[4] as a percentage of apparent consumption	38	44	41	41	45

Recycling: Old (post-consumer) scrap, converted to refined metal, alloys, and other forms, provided an estimated 150,000 tons of copper in 2024, and an estimated 720,000 tons of copper was recovered from new (manufacturing) scrap derived from fabricating operations. Brass and wire-rod mills accounted for approximately 85% of the total copper recovered from scrap. Copper recovered from scrap contributed about 35% of the U.S. copper supply.[5]

Import Sources (2020–23): Copper content of blister and anodes: Finland, 92%; Malaysia, 3%; and other, 5%. Copper content of matte, ash, and precipitates: Canada, 48%; Belgium, 23%; Japan, 13%; Spain, 6%; and other, 10%. Copper content of ore and concentrates: Canada, >99%; and other, <1%. Copper content of scrap: Canada, 46%; Mexico, 42%; Dominican Republic, 3%; and other, 9%. Refined copper: Chile, 65%; Canada, 17%; Mexico, 9%; Peru, 6%; and other, 3%. Refined copper accounted for 88% of all unmanufactured copper imports.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Copper ore and concentrates, copper content	2603.00.0010	1.7¢/kg on lead content.
Unrefined copper anodes	7402.00.0000	Free.
Refined copper and alloys, unwrought	7403.00.0000	1% ad valorem.
Copper scrap	7404.00.0000	Free.
Copper wire rod	7408.11.0000	1% or 3% ad valorem.

Depletion Allowance: 15% (domestic), 14% (foreign).

Government Stockpile: None.

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COPPER

Events, Trends, and Issues: In 2024, production decreased at a majority of copper mines in the United States, and domestic mined copper output declined by an estimated 3% from that in 2023. At the Bingham Canyon Mine in Utah, changes to the mine plan required to mitigate geotechnical risks resulted in lower ore grades and copper recoveries. Production at the Eagle Mine in Michigan was affected by decreased copper ore grades and reduced mill throughput rates owing to a fall of ground along an ore access ramp. Output also decreased at multiple mines in Arizona and New Mexico because of lower ore grades and mining rates. These decreases were partially offset by a significant increase in mined copper production at the Robinson Mine in Nevada owing to planned mine sequencing that yielded higher ore grades and copper recovery rates. At U.S. refineries, copper production increased slightly in 2024 compared with that in 2023. The Kennecott smelter and electrolytic refinery near Salt Lake City, UT, returned to normal operations in the first quarter of 2024 following major rebuilds in 2023. A new secondary copper refinery in Kentucky and a new secondary copper smelter in Georgia were expected to begin operating by yearend 2024.

The COMEX copper price reached a record high in May 2024 and was projected to average $4.20 per pound in full year 2024, an increase of 9% from the annual average price in 2023. Analysts attributed the higher price to multiple factors, such as expectations for reduced global copper supply in the near future, optimistic sentiment regarding world copper demand, strong manufacturing production in China, and decreasing inflation in the United States.

World Mine and Refinery Production and Reserves: Reserves for Canada, Indonesia, Peru, and the United States were revised based on company, Government, and (or) industry association reports.

	Mine production		Refinery production		Reserves[6]
	2023	2024[e]	2023	2024[e]	
United States	1,130	1,100	882	890	47,000
Australia	778	800	442	460	[7]100,000
Canada	500	450	315	320	8,300
Chile	5,250	5,300	2,080	1,900	190,000
China	1,820	1,800	12,000	12,000	41,000
Congo (Kinshasa)	2,930	3,300	2,170	2,500	80,000
Germany	—	—	609	630	—
India	27	30	509	510	2,200
Indonesia	907	1,100	225	350	21,000
Japan	—	—	1,490	1,600	—
Kazakhstan	[e]740	740	458	470	20,000
Korea, Republic of	—	—	604	620	—
Mexico	699	700	509	350	53,000
Peru	2,760	2,600	403	390	100,000
Poland	395	410	592	590	34,000
Russia	[e]890	930	[e]1,000	960	80,000
Zambia	712	680	222	170	21,000
Other countries	3,020	2,700	2,460	2,500	180,000
World total (rounded)	22,600	23,000	27,000	27,000	980,000

World Resources:[6] The most recent U.S. Geological Survey assessment of global copper resources indicated that, as of 2015, identified resources contained 1.5 billion tons of unextracted copper (2.1 billion tons when past production of 0.6 billion tons is included) and undiscovered resources contained an estimated 3.5 billion tons of copper.[8]

Substitutes: Aluminum substitutes for copper in automobile radiators, cooling and refrigeration tube, electrical equipment, and power cable. Optical fiber substitutes for copper in telecommunications applications, and plastics substitute for copper in drain pipe, plumbing fixtures, and water pipe. Titanium and steel are used in heat exchangers.

[e]Estimated. — Zero.
[1]Copper converted to refined metal, alloys, and other forms by brass and wire-rod mills, foundries, refineries, and other manufacturers.
[2]Less than ½ unit.
[3]Primary refined production + copper recovered from old scrap + refined imports – refined exports ± adjustments for refined copper stock changes.
[4]Defined as refined imports – refined exports ± adjustments for refined copper stock changes.
[5]Primary refined production + copper from old and new scrap + refined imports – refined exports ± adjustments for refined copper stock changes.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 27 million tons.
[8]Source: Hammarstrom, J.M., Zientek, M.L., Parks, H.L., Dicken, C.L., and the U.S. Geological Survey Global Copper Mineral Resource Assessment Team, 2019, Assessment of undiscovered copper resources of the world, 2015 (ver. 1.2, December 2021): U.S. Geological Survey Scientific Investigations Report 2018–5160, 619 p. (Accessed November 18, 2024, at https://doi.org/10.3133/sir20185160.)

DIAMOND (INDUSTRIAL)[1]

(Data in million carats unless otherwise specified)

Domestic Production and Use: In 2024, total domestic primary production of manufactured industrial diamond bort, grit, and dust and powder was estimated to be 160 million carats with a value of $53 million, which was a 5% increase from the quantity and value in 2023. No industrial diamond stone was produced domestically. One company with facilities in Florida and Ohio and a second company in Pennsylvania accounted for all domestic primary production. At least four companies produced polycrystalline diamond from diamond powder. At least two companies recovered used industrial diamond material from used diamond drill bits, diamond tools, and other diamond-containing wastes for recycling. The major consuming sectors of industrial diamond are computer chip production; construction; drilling for minerals, natural gas, and oil; machinery manufacturing; stone cutting and polishing; and transportation (infrastructure and vehicles). Highway building, milling, and repair and stone cutting consumed most of the industrial diamond stone. About 99% of U.S. industrial diamond apparent consumption was synthetic industrial diamond because its quality can be controlled, and its properties can be customized.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Bort, grit, and dust and powder; natural and synthetic:					
Production:					
Manufactured diamond[e]	130	132	150	152	160
Secondary	35.0	1.20	14.4	14	14
Imports for consumption	190	261	303	264	230
Exports	90	99	94	74	76
Consumption, apparent[2]	264	295	373	356	330
Price, unit value of imports, dollars per carat	0.19	0.18	0.19	0.16	0.19
Net import reliance[3] as a percentage of apparent consumption	38	55	56	53	47
Stones, natural and synthetic:					
Table Production:					
Manufactured diamond[e]	—	—	—	—	—
Secondary	0.10	0.08	0.08	0.08	0.08
Imports for consumption	0.51	0.33	0.79	0.38	0.34
Exports	0.02	—	([4])	([4])	—
Consumption, apparent[2]	0.59	0.41	0.86	0.46	0.42
Price, unit value of imports, dollars per carat	8.40	13.0	8.40	14.3	11
Net import reliance[3] as a percentage of apparent consumption	83	80	91	83	81

Recycling: In 2024, the amount of diamond bort, grit, and dust and powder recycled was estimated to be 14 million carats with an estimated value of $540,000. An estimated 77,000 carats of diamond stone were recycled with an estimated value of $120,000.

Import Sources (2020–23): Bort, grit, and dust and powder; natural and synthetic: China,[5] 77%; Republic of Korea, 8%; Ireland, 5%; Russia, 3%; and other, 7%. Stones, primarily natural: India, 48%; South Africa, 30%; Russia, 9%; Australia, 4%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Industrial Miners' diamonds:		
Carbonados	7102.21.1010	Free.
Other	7102.21.1020	Free.
Industrial diamonds:		
Simply sawn, cleaved, or bruted	7102.21.3000	Free.
Not worked	7102.21.4000	Free.
Grit or dust and powder of natural diamonds:		
80 mesh or finer	7105.10.0011	Free.
Over 80 mesh	7105.10.0015	Free.
Grit or dust and powder of synthetic diamonds:		
Coated with metal	7105.10.0020	Free.
Not coated with metal, 80 mesh or finer	7105.10.0030	Free.
Not coated with metal, over 80 mesh	7105.10.0050	Free.

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DIAMOND (INDUSTRIAL)

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Most natural industrial diamond is produced as a byproduct of mining gem-quality diamond. Global natural industrial diamond production was essentially the same in 2024 as in the previous year. Russia, the leading country in the production of natural industrial diamond, produced 16 million carats or 41% of total world production, followed by Botswana, 8 million carats (20%); Congo (Kinshasa), 7 million carats (18%); Zimbabwe, 4 million carats (10%); and South Africa, 4 million carats (10%). These five countries produced 99% of the world's natural industrial diamond. In recent years, mines have closed, and output has been lower as mines approach the ends of their lives. The world's largest diamond mines have matured and are past their peak production levels, and several of the largest diamond mines are expected to close in the near future. As these mines are depleted, global production is expected to decline in quantity.

In 2024, U.S. synthetic-industrial-diamond producers did not manufacture any diamond stone. The combined apparent consumption of all types of industrial diamond was essentially unchanged from that of the previous year. Domestic and global consumption of synthetic diamond grit and powder is expected to remain greater than that of natural diamond material. During 2024, imports of all types of natural and synthetic industrial diamond imports decreased by 12% from that in 2023. In 2024, China was the leading producing country of synthetic industrial diamond, followed by the United States and Russia, in descending order of quantity. These three countries produced about 99% of the world's synthetic industrial diamond. Synthetic diamond accounted for more than 99% of global industrial diamond production and consumption. Worldwide production of manufactured industrial diamond totaled more than 15.5 billion carats.

The United States is likely to continue to be one of the world's leading markets for industrial diamond into the next decade and is expected to remain a significant producer of synthetic industrial diamond as well. U.S. demand for industrial diamond is likely to be strong in the construction sector as the United States continues building, milling, and repairing the Nation's highway system. Industrial diamond is impregnated in or coats the cutting edge of saws used to cut concrete in highway construction and repair work.

World Natural Industrial Diamond Mine Production and Reserves: Reserves for Botswana, Russia, and South Africa were revised based on company and Government reports.

	Mine production		Reserves[6]
	2023	2024[e]	
United States	—	—	NA
Angola	1	1	150
Botswana	8	8	250
Congo (Kinshasa)	7	7	150
Russia	16	16	990
South Africa	4	4	85
Zimbabwe	4	4	NA
Other countries	1	1	120
World total (rounded)	41	41	1,700

World Resources:[6] Natural diamond deposits have been discovered in more than 35 countries. Natural diamond accounts for less than 1% of all industrial diamond used; synthetic diamond accounts for the remainder. At least 15 countries have the technology to produce synthetic diamond.

Substitutes: Materials that can compete with industrial diamond in some applications include manufactured abrasives such as cubic boron nitride, fused aluminum oxide, and silicon carbide. Globally, synthetic diamond, rather than natural diamond, is used for more than 99% of industrial applications.

[e]Estimated. NA Not available. — Zero.
[1]See the Gemstones chapter for information on gem-quality diamond.
[2]Defined as manufactured diamond production + secondary diamond production + imports – exports.
[3]Defined as imports – exports.
[4]Less than 500 carats.
[5]Includes Hong Kong.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.

DIATOMITE

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: In 2024, production of diatomite, also known as diatomaceous earth, was estimated to be 880,000 tons with an estimated processed value of $520 million, free on board (f.o.b.) plant. Six companies produced diatomite at 12 mining areas and 9 processing facilities in California, Nevada, Oregon, and Washington. Approximately 65% of diatomite was used in filtration products. The remaining 35% was used in absorbents, lightweight aggregates, fillers, and other applications. A small amount, less than 1%, was used for specialized pharmaceutical and biomedical purposes. The unit value of diatomite varied widely in 2024, from approximately $10 per metric ton when used as a lightweight aggregate in portland cement concrete to more than $1,000 per metric ton for limited specialty markets, including art supplies, cosmetics, and deoxyribonucleic acid (DNA) extraction. The price for diatomite used for filtration was approximately $790 per metric ton.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production[1]	822	998	827	849	880
Imports for consumption	14	14	14	12	15
Exports	66	68	64	53	70
Consumption, apparent[2]	769	944	777	808	830
Price, average value, f.o.b. plant, dollars per metric ton	326	410	416	580	590
Employment, mine and plant, number[e]	370	370	370	370	370
Net import reliance[3] as a percentage of apparent consumption	E	E	E	E	E

Recycling: None.

Import Sources (2020–23): Canada, 57%; Mexico, 15%; Germany, 11%; Argentina, 7%; and other, 10%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Siliceous fossil meals, including diatomite	2512.00.0000	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The amount of domestically produced diatomite sold or used by producers in 2024 was 4% higher than that in 2023. Apparent consumption in 2024 was an estimated 830,000 tons, slightly more than that in 2023. Exports were estimated to have increased by 32% compared with those in 2023. The United States remained the leading global producer and consumer of diatomite. Filtration (including the cleansing of greases and oils and the purification of beer, liquors, water, and wine) continued to be the leading end use for diatomite. An important application for diatomite is the removal of microbial contaminants, such as bacteria, protozoa, and viruses in public water systems. Diatomite continued to be widely used as an inert carrier for pesticides and as an anticaking agent in animal feeds. Caution in the processing and use of diatomite was suggested because many forms contain crystalline silica, which is known to cause cancer, birth defects, or other reproductive harm to humans when exposed to levels above permissible levels.

In April, a leading global producer of industrial minerals headquartered in France entered into negotiations with a Pittsburgh, PA, based global company to acquire its European diatomite and perlite business. The acquisition, which consists of three mining and industrial assets in France and Italy, is expected to be completed by the end of 2024.

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DIATOMITE

In 2024, the United States accounted for an estimated 29% of total world production, followed by Denmark with 18%; China with 12%; and France and Turkey, with 8% each. Smaller quantities of diatomite were mined in 23 additional countries. World production of diatomite in 2024 was essentially unchanged from that in 2023.

World Mine Production and Reserves: Reserves for China, France, and the Republic of Korea were revised based on Government reports.

	Mine production[e]		Reserves[4]
	2023	2024	
United States[1]	849	880	250,000
Argentina	100	100	NA
China	370	370	120,000
Czechia	44	40	NA
Denmark (processed)[5]	530	530	NA
France	250	250	1,000
Germany	50	50	NA
Korea, Republic of	50	50	2,200
Mexico	100	100	NA
Mozambique	50	50	NA
Peru	100	100	NA
Russia	50	50	NA
Spain	50	50	57,000
Turkey	240	240	44,000
Other countries	172	170	NA
World total (rounded)	3,010	3,000	Large

World Resources:[4] Diatomite deposits form from an accumulation of amorphous hydrous silica cell walls of dead diatoms in oceanic and fresh waters. Diatomite is also known as kieselguhr (Germany), moler (an impure Danish form), and tripolite (after an occurrence near Tripoli, Libya). Because U.S. diatomite occurrences are at or near Earth's surface, recovery from most deposits is achieved through low-cost, open pit mining. Outside the United States, however, underground mining is fairly common owing to deposit location and topographic constraints. World resources of crude diatomite are adequate for the foreseeable future.

Substitutes: Many materials can be substituted for diatomite. However, the unique properties of diatomite assure its continued use in many applications. Expanded perlite and silica sand compete for filtration. Filters made from manufactured materials, notably ceramic, polymeric, or carbon membrane filters and filters made with cellulose fibers, are becoming competitive as filter media. Alternate filler materials include clay, ground limestone, ground mica, ground silica sand, perlite, talc, and vermiculite. For thermal insulation, materials such as various clays, exfoliated vermiculite, expanded perlite, mineral wool, and special brick can be used. Transportation costs will continue to determine the maximum economic distance that most forms of diatomite may be shipped and still remain competitive with alternative materials.

[e]Estimated. E Net exporter. NA Not available.
[1]Processed ore sold or used by producers.
[2]Defined as production + imports – exports.
[3]Defined as imports – exports.
[4]See Appendix C for resource and reserve definitions and information concerning data sources.
[5]Includes sales of moler production.

FELDSPAR AND NEPHELINE SYENITE

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: U.S. feldspar production in 2024 had an estimated value of $51 million. Feldspar was produced by six companies in California, Idaho, North Carolina, and Virginia. In addition to feldspar, processors reported recovery of mica and silica sand. Two companies produced nepheline syenite in Arkansas, but production data were not available.

Feldspar is ground to about 20 mesh for glassmaking and to 200 mesh or finer for most ceramic and filler applications. Domestically produced feldspar was estimated to have been transported by ship, rail, or truck to at least 30 States and to foreign destinations, including Canada and Mexico. In pottery and glass, feldspar and nepheline syenite function as a flux. Glass manufacturing accounted for an estimated 50% of the 2024 end-use distribution of domestic feldspar and nepheline syenite; ceramic tile, pottery, and other uses accounted for the remaining 50%.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production, feldspar, marketable[1]	480	420	430	450	450
Imports for consumption:					
Feldspar	43	169	276	68	220
Nepheline syenite	503	529	484	440	470
Exports:					
Feldspar	3	4	3	7	7
Nepheline syenite	13	15	18	13	8
Consumption, apparent:[2]					
Feldspar[1]	520	590	703	510	670
Nepheline syenite	489	514	466	427	460
Price, average unit value, dollars per metric ton:					
Feldspar only, marketable production[e]	104	103	104	104	110
Nepheline syenite, imports	163	164	183	195	200
Employment, mine, preparation plant, and office, number[e]	220	180	150	160	170
Net import reliance[3] as a percentage of apparent consumption:					
Feldspar	9	30	39	12	33
Nepheline syenite	>95	>95	>95	>95	>95

Recycling: Feldspar and nepheline syenite are not recycled by producers; however, glass container producers use cullet (recycled container glass), thereby reducing feldspar and nepheline syenite consumption.

Import Sources (2020–23): Feldspar: Turkey, 92%; Mexico, 6%; and other, 2%. Nepheline syenite: Canada, 99%; and other, 1%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Feldspar	2529.10.0000	Free.
Nepheline syenite	2529.30.0010	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: In 2024, estimated domestic production and sales of feldspar were unchanged, and the average unit value increased by 6% compared with that in 2023. Estimated imports of feldspar more than tripled, and imports of nepheline syenite increased by 7% compared with those in 2023.

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FELDSPAR AND NEPHELINE SYENITE

In the United States, new residential construction housing starts, for which feldspar is a raw material commonly used in the manufacture of plate glass, ceramic tiles and sanitaryware, and insulation, decreased slightly compared with those in 2023 based on data through September 2024. In 2024, the value of the global glass packaging industry was estimated to increase by almost 40% compared with that in 2023. The increase was largely attributed to increased use of glass beverage containers, which accounted for more than one-half of the feldspar consumed by the glass industry. Glass—including beverage containers, plate glass, and fiberglass insulation for housing and building construction—accounted for 50% of end uses of feldspar in the United States.

On September 26, the two feldspar producers in North Carolina temporarily shut down operations owing to Hurricane Helene. After the hurricane, there was minor damage to both companies' operations, and both companies were able to ramp up to full capacity and resume shipments from their operations in October.

World Mine Production and Reserves:[4] Reserves for Iran and the Republic of Korea were revised based on Government reports.

	Mine production[e]		Reserves[5]
	2023	2024	
United States[1]	450	450	NA
Brazil (beneficiated, marketable)	[6]622	420	150,000
China	2,500	2,500	730,000
India	6,000	6,000	320,000
Iran	3,100	3,100	130,000
Italy	2,200	2,200	NA
Korea, Republic of	[6]991	990	200,000
Morocco	590	590	NA
Russia	650	650	NA
Saudi Arabia	650	650	NA
Spain (includes pegmatites)	990	990	NA
Thailand	2,000	2,000	45,000
Turkey	[6]9,480	9,500	720,000
Other countries	3,220	3,200	NA
World total (rounded)	33,400	33,000	Large

World Resources:[5] Identified and undiscovered resources of feldspar are more than adequate to meet anticipated world demand. Quantitative data on resources of feldspar existing in feldspathic sands, granites, and pegmatites generally have not been compiled. Ample geologic evidence indicates that resources are large, although not always conveniently accessible to the principal centers of consumption.

Substitutes: Imported nepheline syenite was the major alternative material for feldspar. Feldspar can be replaced in some of its end uses by clays, electric furnace slag, feldspar-silica mixtures, pyrophyllite, spodumene, or talc.

[e]Estimated. NA Not available.
[1]Rounded to two significant digits to avoid disclosing company proprietary data.
[2]Defined as production + imports – exports.
[3]Defined as imports – exports.
[4]Feldspar only.
[5]See Appendix C for resource and reserve definitions and information concerning data sources.
[6]Reported.

FLUORSPAR

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: In 2024, minimal fluorspar (calcium fluoride, CaF_2) was produced in the United States. One company sold fluorspar from stockpiles produced as a byproduct of its limestone quarrying operation in Cave-In-Rock, IL. In February, a second company started the construction process for a fluorspar mine in Utah, including installation of a ramp that reached its targeted drilling depth in August. The mined fluorspar was expected to supply the company's lumps-processing plant that was under construction in Delta, UT. Completion of the processing plant was anticipated by yearend. U.S. fluorspar consumption was satisfied by imports. Domestically, CaF_2 was used in the production of anhydrous hydrogen fluoride (HF) in Louisiana and Texas and was by far the leading use for acid-grade fluorspar. Aqueous HF is the primary feedstock for the manufacture of virtually all fluorine-bearing chemicals, particularly refrigerants and fluoropolymers, and is a key ingredient in the processing of aluminum and uranium. Other uses of fluorspar were in cement production, in enamels, as a flux in steelmaking, in glass manufacture, in iron and steel casting, and in welding rod coatings.

The U.S. Department of Energy continued to produce aqueous HF as a byproduct of the conversion of depleted uranium hexafluoride to depleted uranium oxide at plants in Paducah, KY, and Portsmouth, OH; the aqueous HF was sold into the commercial market. An estimated 40,000 tons of fluorosilicic acid (FSA), equivalent to about 65,000 tons of fluorspar grading 100% CaF_2, was recovered from three phosphoric acid plants that processed phosphate rock. A company in Aurora, NC, started production of anhydrous HF from FSA in 2024.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production:					
Finished, metallurgical grade	NA	NA	NA	NA	NA
Fluorosilicic acid from phosphate rock	22	40	43	43	40
Imports for consumption:					
Acid grade	427	391	448	381	400
Metallurgical grade	65	59	84	31	40
Total fluorspar imports	492	451	532	412	440
Hydrofluoric acid	103	103	99	87	75
Aluminum fluoride	21	28	21	25	24
Cryolite	26	42	28	32	24
Exports, fluorspar, all grades[1]	9	15	24	20	15
Consumption, apparent[2]	483	436	508	392	430
Price, average unit value of imports, cost, insurance, and freight, dollars per metric ton:					
Acid grade	309	322	387	429	470
Metallurgical grade	149	151	206	296	400
Employment, mine, number[e]	16	17	15	16	15
Net import reliance[2] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Synthetic fluorspar may be produced from neutralization of waste in the enrichment of uranium, petroleum alkylation, and stainless-steel pickling; however, undesirable impurities constrain use. Primary aluminum producers recycle HF and fluorides from smelting operations.

Import Sources (2020–23):[3] Mexico, 62%; Vietnam, 14%; South Africa, 9%; China,[4] 8%; and other, 7%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Metallurgical grade (97% or less CaF_2)	2529.21.0000	Free.
Acid grade (more than 97% CaF_2)	2529.22.0000	Free.
Natural cryolite	2530.90.1000	Free.
Hydrogen fluoride (hydrofluoric acid)	2811.11.0000	Free.
Aluminum fluoride	2826.12.0000	Free.
Sodium hexafluoroaluminate (synthetic cryolite)	2826.30.0000	Free.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile: None.

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FLUORSPAR

Events, Trends, and Issues: In 2024, world production of fluorspar was an estimated 9.5 million tons compared with 9.53 million tons in 2023. The supply of fluorspar in China was constrained by country-wide safety inspections and rectification of fluorspar mining issued by the Ministry of Natural Resources and conducted by the Mine Safety Administration from March through August. During this time, operations ceased while the mines were consolidated and upgraded to prevent accidents, which have become frequent in recent years. As a result, China's imports of fluorspar increased by 55% in the first half of 2024, mainly from Mongolia. This increase may also be attributed to the elimination of the 3% import tax on low-arsenic fluorspar by China's Ministry of Finance, which was used to produce HF and other downstream products used in lithium-ion batteries, such as binders, electrolyte salts, and separator coatings.

In February, the new owners of a fluorspar mine in Canada announced plans to restart operations in 2025 after the mine was idled in 2022. Several other fluorspar mines were in development or in the process of reopening in Australia, Germany, Kenya, and the United States.

To meet the goals of the American Innovation and Manufacturing Act (AIM Act) of 2020 and the planned phase down of hydrofluorocarbons (HFCs), the allowance quotas for HFC production and consumption were reduced to 40% below the historic baseline effective January 1, 2024. This limited the volume of legacy HFC refrigerants that could be imported or produced. In May, a U.S. chemical company decided to cease sales of certain HFCs used in commercial refrigeration equipment. For those not found in compliance with the regulatory requirements of the AIM Act, the U.S. Environmental Protection Agency (EPA) has outlined certain administrative consequences. As of September, the EPA has issued administrative consequences to 52 entities in accordance with the regulatory provisions, which include allowance adjustments. Under this authority, the EPA can retire, revoke, or withhold allowances and impose bans on receiving future allowances.

World Mine Production and Reserves: Reserves for China, Iran, and Vietnam were revised based on company and Government reports.

	Mine production[e]		Reserves[5]
	2023	2024	
United States	NA	NA	NA
China	6,000	5,900	86,000
Germany	100	100	NA
Iran	121	120	7,600
Mexico	[6]1,160	1,200	68,000
Mongolia	1,210	1,200	34,000
Pakistan	55	52	NA
South Africa	345	380	41,000
Spain	165	160	15,000
Thailand	48	76	3,600
Vietnam	[6]146	110	16,000
Other countries	180	170	46,000
World total (rounded)	9,530	9,500	320,000

World Resources:[5, 7] Large quantities of fluorine are present in phosphate rock. Current U.S. reserves of phosphate rock are estimated to be 1 billion tons, containing about 72 million tons of 100% fluorspar equivalent assuming an average fluorine content of 3.5% in the phosphate rock. World reserves of phosphate rock are estimated to be 74 billion tons, containing about 5 billion tons of 100% fluorspar equivalent.

Substitutes: FSA has been used as an alternative to fluorspar in the production of AlF_3 and HF. Because of differing physical properties, AlF_3 produced from FSA is not readily substituted for AlF_3 produced from fluorspar. Aluminum smelting dross, borax, calcium chloride, iron oxides, manganese ore, silica sand, and titanium dioxide have been used as substitutes for fluorspar fluxes.

[e]Estimated. NA Not available.

[1]Includes data for the following Schedule B numbers: 2529.21.0000 and 2529.22.0000.

[2]Defined as total fluorspar imports – exports.

[3]Includes data for the following Harmonized Tariff Schedule of the United States codes: 2529.21.0000 and 2529.22.0000.

[4]Includes Hong Kong.

[5]See Appendix C for resource and reserve definitions and information concerning data sources.

[6]Reported.

[7]Measured as 100% CaF_2.

GALLIUM

(Data in kilograms, gallium content, unless otherwise specified)

Domestic Production and Use: No domestic primary (low-purity, unrefined) gallium has been recovered since 1987. Globally, primary gallium is recovered as a byproduct of processing bauxite and zinc ores. One company in New York recovered and refined high-purity gallium from imported primary low-purity gallium metal and new scrap. In 2024, the value of imports of gallium metal was an estimated $4 million, and the value of gallium arsenide (GaAs) wafer imports was an estimated $140 million, increases in value of 33% and 24%, respectively, from those in 2023. GaAs was used to manufacture compound semiconductor wafers used in integrated circuits (ICs) and optoelectronic devices, which include laser diodes, light-emitting diodes (LEDs), photodetectors, and solar cells. Gallium nitride (GaN) was used to manufacture ICs and optoelectronic devices; ICs accounted for 79% of domestic gallium consumption, optoelectronic devices accounted for 20%, and research and development accounted for 1%. About 83% of the gallium consumed in the United States was in GaAs, GaN, and gallium phosphide wafers. Gallium metal, triethyl gallium, and trimethyl gallium, used in the epitaxial layering process to fabricate epiwafers for the production of ICs and LEDs, accounted for most of the remainder. Optoelectronic devices were used in aerospace applications, consumer goods, industrial equipment, medical equipment, and telecommunications equipment. Uses of ICs included defense applications, high-performance computers, and telecommunications equipment.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, primary	—	—	—	—	—
Imports for consumption:					
Metal	4,430	8,890	11,350	11,400	11,000
Gallium arsenide wafers (gross weight)	208,000	306,000	424,000	163,000	180,000
Exports	NA	NA	NA	NA	NA
Consumption, reported	15,700	17,100	19,700	19,200	19,000
Price, average unit value of imports, dollars per kilogram:					
High-purity, refined[1]	596	625	560	450	500
Low-purity, primary[2]	163	254	394	288	220
Stocks, consumer, yearend	2,920	2,810	2,780	2,760	2,700
Net import reliance[3] as a percentage of reported consumption	100	100	100	100	100

Recycling: Old scrap, none. Substantial quantities of new scrap generated in the manufacture of GaAs-based devices were reprocessed to recover high-purity gallium at one facility in New York. An Australian company plans to open an industrial electronic scrap recycling plant in the United States with an initial focus on gallium recovery.

Import Sources (2020–23): Metal: Japan, 24%; China, 19%; Germany, 19%; Canada, 17%; and other, 21%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Gallium arsenide wafers, undoped	2853.90.9010	2.8% ad valorem.
Gallium arsenide wafers, doped	3818.00.0010	Free.
Gallium metal	8112.92.1000	3% ad valorem.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: Not available.

Events, Trends, and Issues: Imports of gallium metal, GaAs wafers, and GaN wafers and domestic production of GaAs and GaN wafers continued to account for all U.S. consumption of gallium. In 2024, gallium metal imports decreased by 4% owing to decreased imports from China, Japan, Russia, and Slovakia. In August 2023, China's Government implemented gallium export controls, requiring licensing procedures to be carried out by China's gallium exporters. After a decrease in exports for the remainder of 2023, China's gallium exports have recovered in 2024 as export licenses have been granted. In December 2024, China banned all exports of gallium to the United States.

Primary low-purity (99.99%-pure) gallium prices in China averaged $380 per kilogram in June 2024, an increase of 17% from $325 per kilogram in January 2024, and an increase of 58% from $240 per kilogram in June 2023. China's gallium prices increased in the first half of 2024 owing to global concern about reduced gallium availability following China's implementation of gallium export controls. The controls required all exports have a committed end which made rebuilding limited stock outside of China difficult. By October, primary low-purity gallium prices in China increased by 11% to $420 per kilogram as stocks outside of China depleted further.

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GALLIUM

China accounted for 99% of worldwide primary low-purity gallium production. The remaining primary low-purity gallium producers outside of China included Japan, the Republic of Korea, and Russia. Germany, Hungary, and Kazakhstan ceased primary production in 2016, 2015, and 2013, respectively. Ukraine most likely ceased primary production in 2022 because of the conflict with Russia. Owing to China's 2023 gallium export controls, the United States and other countries are pursuing the start or restart of domestic primary gallium production. At least one company is exploring the feasibility of producing domestic primary gallium.

World high-purity refined gallium production in 2024 was estimated to be about 320,000 kilograms, unchanged from the estimate for 2023. Canada, China, Japan, Slovakia, and the United States were the known principal producers of high-purity refined gallium. The United Kingdom ceased high-purity refined gallium production in 2018. Gallium was recovered from new scrap in Canada, China, Japan, Slovakia, and the United States. World high-purity refined gallium production capacity was an estimated 340,000 kilograms per year, and secondary high-purity gallium production capacity was an estimated 280,000 kilograms per year.

World Low-Purity Production and Production Capacity:

	Primary production		Production capacity
	2023	2024[e]	2024
United States	—	—	—
China	[4]621,000	[4]750,000	1,000,000
Japan[e]	3,000	3,000	10,000
Korea, Republic of[e]	3,000	3,000	16,000
Russia[e]	6,000	6,000	10,000
Other countries[5]	—	—	[e]88,000
World total (rounded)	633,000	760,000	[e]1,100,000

World Resources:[6] Gallium occurs in very small concentrations in ores of other metals. Most gallium is produced as a byproduct of processing bauxite, and the remainder is produced from zinc-processing residues. The average gallium content of bauxite is 50 parts per million. U.S. bauxite deposits consist mainly of subeconomic resources that are not generally suitable for alumina production owing to their high silica content. Some domestic zinc ores contain up to 50 parts per million gallium and could be a significant resource, although no gallium is currently recovered from domestic ores. Gallium contained in world resources of bauxite is estimated to exceed 1 million tons, and a considerable quantity could be contained in world zinc resources. However, less than 10% of the gallium in bauxite and zinc resources is potentially recoverable.

Substitutes: Liquid crystals made from organic compounds are used in visual displays as substitutes for LEDs. Silicon-based complementary metal-oxide semiconductor power amplifiers compete with GaAs power amplifiers in midtier third-generation (3G) cellular handsets. Indium phosphide components can be substituted for GaAs-based infrared laser diodes in some specific-wavelength applications, and helium-neon lasers compete with GaAs in visible laser diode applications. Silicon is the principal competitor with GaAs in solar-cell applications. In many defense-related applications, GaAs- and GaN-based ICs are used because of their unique properties, and no effective substitutes exist for GaAs and GaN in these applications. In heterojunction bipolar transistors, GaAs is being replaced in some applications by silicon-germanium.

[e]Estimated. NA Not available. — Zero.
[1]Estimated based on the average unit values of U.S. imports for 99.999%- and 99.99999%-pure gallium.
[2]Estimated based on the average unit values of U.S. imports for 99.99%-pure gallium.
[3]Defined as imports – exports. Excludes gallium arsenide wafers.
[4]Estimated from China Nonferrous Metals Industry Association article. Source: Argus Media Group, Argus Non-Ferrous Markets.
[5]Other countries estimated to still have primary low-purity gallium production capacity include Germany, Hungary, Kazakhstan, and Ukraine.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.

GARNET (INDUSTRIAL)[1]

(Data in metric tons unless otherwise specified)

Domestic Production and Use: In 2024, garnet for industrial use was mined by three companies—one in Montana and two in New York. One processing facility operated in Oregon and another operated in Pennsylvania. The estimated value of crude garnet production was $17 million, and refined material sold or used had an estimated value of $50 million. The major end uses of garnet were, in descending percentage of consumption, for abrasive blasting, water-filtration media, water-jet-assisted cutting, and other end uses, such as in abrasive powders, nonslip coatings, and sandpaper. Domestic industries that consume garnet include aircraft and motor vehicle manufacturers, ceramics and glass producers, electronic component manufacturers, filtration plants, glass polishing, the petroleum industry, shipbuilders, textile stonewashing, and wood-furniture-finishing operations.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Crude	101,000	81,700	76,400	71,900	80,000
Refined, sold or used	177,000	155,000	172,000	167,000	140,000
Imports for consumption[2]	116,000	145,000	268,000	151,000	100,000
Exports	18,200	20,400	23,300	20,000	25,000
Consumption, apparent[3]	198,000	205,000	321,000	203,000	160,000
Price, average import unit value, dollars per metric ton	250	280	194	211	170
Employment, mine and mill, number[e]	130	120	90	74	110
Net import reliance[4] as a percentage of apparent consumption	49	61	76	65	48

Recycling: Garnet was recycled at a plant in Oregon with a recycling capacity of 16,000 tons per year and at a plant in Pennsylvania with a recycling capacity of 25,000 tons per year. Garnet can be recycled multiple times without significant degradation of its quality. Most recycled garnet is from blast cleaning and water-jet-assisted cutting operations.

Import Sources (2020–23):[e] South Africa, 54%; Australia, 21%; India, 11%; China,[5] 9%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Emery, natural corundum, natural garnet, and other natural abrasives:		
Crude	2513.20.1000	Free.
Other than crude	2513.20.9000	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: During 2024, estimated domestic production of crude garnet concentrates increased by 12% compared with production in 2023. U.S. garnet production was estimated to be 8% of total global garnet production. The 2024 estimated domestic amount of refined garnet sold or used decreased by 15% compared with refined garnet sold or used in 2023.

Garnet imports in 2024 were estimated to have decreased by 31% compared with those in 2023. This decrease was attributed to large decreases in garnet imports from Australia and South Africa. In 2024, the average unit value of garnet imports was $170 per ton, an 18% decrease compared with the average unit value in 2023. In the United States, the average price of domestically produced crude garnet concentrate was about $220 per ton. U.S. exports in 2024 were estimated to have increased by 23%. During 2024, the United States consumed an estimated 160,000 tons of garnet, a 21% decrease from that in 2023.

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GARNET (INDUSTRIAL)

The U.S. natural gas and petroleum industry is one of the leading garnet-consuming industries, using garnet for cleaning drill pipes and well casings. Natural gas and petroleum producers also use garnet as a reservoir-fracturing proppant, alone or mixed with other proppants. At the beginning of 2024, the number of drill rigs operating in the United States was 622.[6] By the end of the first week of October 2024, the number of rigs operating had declined to 585,[6] likely indicating that less garnet was consumed in well drilling. Rig counts remained 39% lower than that in the same period in 2019 before the global coronavirus disease 2019 (COVID-19) pandemic in 2020.

The garnet market is very competitive. To increase profitability and remain competitive with imported material, production may be restricted to only high-grade garnet ores or as a byproduct of other salable mineral products that occur with garnet, such as kyanite, marble, metallic ore minerals, mica minerals, sillimanite, staurolite, or wollastonite.

World Mine Production and Reserves: Reserves for South Africa were revised based on company and Government reports.

	Mine production[e]		Reserves[7]
	2023	2024	
United States	71,900	80,000	5,000,000
Australia	390,000	390,000	Moderate to large
China	310,000	310,000	37,000,000
Czechia	3,000	3,000	NA
India	15,000	15,000	8,600,000
Pakistan	1,900	1,900	NA
South Africa	180,000	180,000	880,000
World total (rounded)	972,000	980,000	Moderate to large

World Resources:[7] World resources of garnet are large and occur in a wide variety of rocks, particularly gneisses and schists. Garnet also occurs in contact-metamorphic deposits in crystalline limestones, pegmatites, and serpentinites and in vein deposits. In addition, alluvial garnet is present in many heavy-mineral sand and gravel deposits throughout the world. Large domestic resources of garnet also are concentrated in coarsely crystalline gneiss near North Creek, NY; other significant domestic resources of garnet occur in Idaho, Maine, Montana, New Hampshire, North Carolina, and Oregon. In addition to those in the United States, major garnet deposits exist in Australia, China, Czechia, India, Pakistan, and South Africa where they are mined for foreign and domestic markets. Deposits in Russia and Turkey also have been mined primarily, for internal markets but production data were not reported. Additional garnet resources are in Canada, Chile, Spain, Thailand, and Ukraine; small mining operations have been reported in most of these countries, but available information was inadequate to make reliable estimates of their individual output.

Substitutes: Other natural and manufactured abrasives can substitute to some extent for all major end uses of garnet. In many cases, however, using the substitutes would entail increased cost or decreased quality. Fused aluminum oxide and staurolite compete with garnet as a sandblasting material. Ilmenite, magnetite, and plastics compete as filtration media. Corundum, diamond, and fused aluminum oxide compete for lens grinding and for many lapping operations. Emery is a substitute in nonskid surfaces. Fused aluminum oxide, quartz sand, and silicon carbide compete for the finishing of plastics, wood furniture, and other products.

[e]Estimated. NA Not available.
[1]Excludes gem and synthetic garnet. All percentages are calculated using unrounded data.
[2]Sources: U.S. Census Bureau and Trade Mining, LLC; data adjusted by the U.S. Geological Survey.
[3]Defined as crude production + imports – exports.
[4]Defined as imports – exports.
[5]Includes Hong Kong.
[6]Source: Baker Hughes Co., 2024, North America rotary rig count: Baker Hughes Co. (Accessed October 9, 2024, at https://bakerhughesrigcount.gcs-web.com/na-rig-count.)
[7]See Appendix C for resource and reserve definitions and information concerning data sources.

GEMSTONES[1]

(Data in million dollars unless otherwise specified)

Domestic Production and Use: The combined value of U.S. natural and synthetic gemstone output in 2024 was an estimated $73 million, an 8% decrease compared with that in 2023. Domestic natural gemstone production included agate, beryl, coral, diamond, garnet, jade, jasper, opal, pearl, quartz, sapphire, shell, topaz, tourmaline, turquoise, and many other gem materials. In descending order of production value, Arizona led the Nation in natural gemstone production, followed by Oregon, Nevada, California, Montana, and Maine. These six States accounted for 71% of the natural gemstone production in the United States. Synthetic gemstones were manufactured by eight companies in North Carolina, California, Oregon, Maryland, New York, South Carolina, Wisconsin, and Arizona, in descending order of production value. U.S. synthetic gemstone production decreased by 9% compared with that in 2023. Major gemstone end uses were carvings, gem and mineral collections, and jewelry.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:[2]					
Natural[3]	9.82	9.48	9.95	10.0	10
Laboratory-created (synthetic)	55.0	79.3	87.1	69.0	63
Imports for consumption	16,300	24,600	28,700	24,800	20,000
Exports, excluding reexports	1,330	992	1,890	3,610	2,000
Consumption, apparent[4]	15,000	23,700	26,900	21,300	18,000
Price	Variable, depending on size, type, and quality				
Employment, mine, number[e]	1,100	1,100	1,100	1,100	1,100
Net import reliance[5] as a percentage of apparent consumption	99	99	99	99	99

Recycling: Gemstones are often recycled by being resold as estate jewelry, reset, or recut, but this report does not account for those stones.

Import Sources (2020–23, by value): Diamond: India, 47%; Israel, 26%; Belgium, 11%; South Africa, 5%; and other, 11%. Diamond imports accounted for an average of 82% of the total value of gem imports in 2024.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Coral and similar materials, unworked	0508.00.0000	Free.
Imitation gemstones	3926.90.4000	2.8% ad valorem.
Imitation pearls and imitation pearl beads, not strung	7018.10.1000	4% ad valorem.
Imitation gemstones	7018.10.2000	Free.
Pearls, natural, graded and temporarily strung	7101.10.3000	Free.
Pearls, natural, other	7101.10.6000	Free.
Pearls, cultured	7101.21.0000	Free.
Diamonds, unworked or sawn	7102.31.0000	Free.
Diamonds, cut, 0.5 carat or less	7102.39.0010	Free.
Diamonds, cut, more than 0.5 carat	7102.39.0050	Free.
Other nondiamond gemstones, unworked	7103.10.2000	Free.
Other nondiamond gemstones, uncut	7103.10.4000	10.5% ad valorem.
Rubies, cut	7103.91.0010	Free.
Sapphires, cut	7103.91.0020	Free.
Emeralds, cut	7103.91.0030	Free.
Other nondiamond gemstones, cut	7103.99.1000	Free.
Other nondiamond gemstones, worked	7103.99.5000	10.5% ad valorem.
Synthetic diamonds, unworked or roughly shaped	7104.21.0000	3% ad valorem.
Synthetic gemstones, unworked or roughly shaped	7104.29.0000	3% ad valorem.
Synthetic diamonds, cut but not set	7104.91.1000	Free.
Synthetic diamonds, other	7104.91.5000	6.4% ad valorem.
Synthetic gemstones, worked or cut but not set	7104.99.1000	Free.
Synthetic gemstones, other	7104.99.5000	6.4% ad valorem.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

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GEMSTONES

Events, Trends, and Issues: Total world diamond production in 2024 was essentially unchanged from that in 2023. In 2024, Russia was the world's leading diamond producer and exporter by volume. Russia's state-owned diamond mining company accounted for nearly one-third of global natural diamond production. The United States was one of the world's leading markets for polished diamonds. In April 2022, the U.S. Government banned the import of rough and finished gem-grade diamonds from Russia, and the U.S. Department of the Treasury placed sanctions on the Russian state-owned diamond-mining company to prevent diamond revenues from funding the conflict with Ukraine. The Group of Seven (G7; representatives of the seven leading industrial nations) also announced a ban on Russian diamonds in December 2023, with the goal of limiting Russia's ability to fund its conflict with Ukraine through diamond sales. The European Union (EU) included the G7 diamond ban into its sanctions package against Russia, making it legally binding on EU member states. The EU ban included diamonds processed in third countries and went into effect on March 1, 2024.

In 2023 and 2024, the global natural diamond market experienced a slowdown, which affected the entire diamond pipeline. Fewer jewelry sales led to a decline in trading of polished diamonds and a buildup of midstream inventory, which in turn led to a decline in diamond rough sales and lower prices, affecting the ability of mining companies to maintain operations. This slowdown resulted from decreased demand for luxury goods and an increasing popularity of synthetic diamonds.

In 2024, U.S. imports for consumption of gemstones were valued at about $20 billion, which was a 19% decrease compared with $24.8 billion in 2023. The decrease in U.S. total gemstone imports combined with the value of domestic exports contributed to a 15% decrease in apparent consumption to a value of $18 billion in 2024 compared with $21.3 billion in 2023. The United States was one of the leading global markets in terms of sales and is expected to continue as a dominant global gemstone consumer.

World Gem-Quality Natural Diamond Mine Production and Reserves:[6]

	Mine production		Reserves[7]
	2023	2024[e]	
United States	—	—	NA
Angola	8,780	8,800	150,000
Botswana	17,600	18,000	250,000
Canada	16,000	16,000	110,000
Congo (Kinshasa)	1,670	1,700	150,000
Ghana	203	200	NA
Guinea	96	96	NA
Lesotho	472	470	NA
Namibia	2,390	2,400	NA
Russia	20,900	21,000	990,000
Sierra Leone	420	420	NA
South Africa	2,360	2,400	85,000
Tanzania	162	160	NA
Zimbabwe	491	490	NA
Other countries	280	280	120,000
World total (rounded)	71,800	72,000	>2,000,000

World Resources:[7] Most diamond ore bodies have a diamond content that ranges from less than 1 carat to about 6 carats per ton of ore. The major diamond reserves are in southern Africa, Australia, Canada, and Russia.

Substitutes: Glass, plastics, and other materials are substituted for natural gemstones. Synthetic gemstones (manufactured materials that have the same chemical and physical properties as natural gemstones) are common substitutes. Simulants (materials that appear to be gems but differ in chemical and physical characteristics) also are frequently substituted for natural gemstones.

[e]Estimated. NA Not available. — Zero.
[1]Excludes industrial diamond and industrial garnet. See the Diamond (Industrial) and Garnet (Industrial) chapters.
[2]Estimated minimum production.
[3]Includes production of freshwater shell.
[4]Defined as production (natural and synthetic) + imports (natural and synthetic) – exports (natural and synthetic, excluding reexports).
[5]Defined as imports (natural and synthetic) – exports (natural and synthetic, excluding reexports).
[6]Data in thousands of carats of natural diamond.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.

GERMANIUM

(Data in kilograms, germanium content, unless otherwise specified)

Domestic Production and Use: In 2024, zinc concentrates containing germanium were produced at a mine in Alaska. Some of the germanium-containing concentrates produced in Alaska were exported to a refinery in Canada for processing and germanium recovery in the form of dioxide and tetrachloride. Operations at a mine in Tennessee that also produced germanium-containing zinc concentrates remained suspended during the year. Prior to the suspension, the zinc concentrates were sent to a zinc smelter in Clarksville, TN, which recovered the germanium in the form of an intermediate leach concentrate for export. The value of germanium metal and germanium dioxide (gross weight) imported domestically in 2024 was estimated to be $50 million. A company in St. George, UT, produced germanium wafers mostly for solar cells used in satellites from imported and recycled germanium. A company in Quapaw, OK, produced germanium tetrachloride for the production of fiber optics from imported and recycled germanium materials.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, refinery:					
Primary	—	—	—	—	—
Secondary	NA	NA	NA	NA	NA
Imports for consumption:[e, 1]					
Germanium metal	14,000	13,000	14,000	22,000	20,000
Germanium dioxide	12,000	17,000	15,000	14,000	13,000
Germanium tetrachloride	NA	NA	NA	NA	NA
Exports:[e, 1]					
Germanium metal	4,000	5,500	6,600	6,000	7,200
Germanium dioxide	810	430	130	110	120
Germanium tetrachloride	NA	NA	NA	NA	NA
Shipments from Government stockpile[2]	—	—	—	NA	NA
Consumption, estimated[3]	30,000	30,000	NA	NA	NA
Price, annual average, dollars per kilogram:[4]					
Germanium metal	1,046	1,187	1,294	1,392	2,100
Germanium dioxide	724	770	828	883	1,400
Net import reliance[5] as a percentage of estimated consumption	>50	>50	>50	>50	>50

Recycling: The United States has the capability to recycle new and old germanium scrap. During the manufacture of infrared germanium optics, much of the germanium removed during the machining process is routinely recycled as new scrap. Infrared lenses and windows in decommissioned military equipment also are recycled to recover germanium. Germanium is recycled from certain wastes generated during the manufacture of optical fibers. Germanium wafers used as substrates to produce solar cells also are recycled. Available information was inadequate to make reliable estimates of the amount of secondary germanium produced.

Import Sources (2020–23):[1] Germanium metal: China, 51%; Belgium, 27%; Germany, 15%; Russia, 5%; and other, 2%. Germanium dioxide: Belgium, 53%; Canada, 41%; and other, 6%. Combined total: Belgium, 42%; Canada, 23%; China, 23%; Germany, 7%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Germanium oxides and zirconium dioxide	2825.60.0000	3.7% ad valorem.
Unspecified chlorides, including germanium tetrachloride	2827.39.9000	3.7% ad valorem.
Metal, unwrought	8112.92.6000	2.6% ad valorem.
Metal, powder	8112.92.6500	4.4% ad valorem.
Metal, wrought	8112.99.1000	4.4% ad valorem.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile:[6]

	FY 2024		FY 2025	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Germanium (gross weight)	—	5,000	—	5,000

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GERMANIUM

Events, Trends, and Issues: The major end uses of germanium in the United States, in descending order, were fiber optics, infrared optics, semiconductor applications and solar cells, and radiation detectors. In the fiber optics industry, germanium dioxide and tetrachloride were consumed during the manufacture of fiber optic glass used for data networking and telecommunication. Germanium metal was processed into lenses for infrared optical systems used in commercial and government markets, fabricated into wafers used as substrates to produce multijunction solar cells used in space applications, and consumed to produce high-purity germanium radiation detectors. Germanium compounds were consumed to produce germane gas used in certain types of semiconductor and solar cell manufacturing. U.S. imports of germanium metal and dioxide (germanium content) were estimated to have decreased by about 8% in 2024 from those in 2023 to 33,000 kilograms. More than 94% of total imports of metal and dioxide (germanium content) for the year through August were from Belgium, Germany, Canada, and China in descending order by quantity. In December 2024, China banned all exports of germanium to the United States.

In April, the U.S. Department of Defense awarded a company $14.4 million to expand and upgrade its germanium wafer manufacturing capabilities at its facility in St. George, UT. The funding was awarded under the Defense Production Act Investment Program and supported the 2024 National Defense Industrial Strategy to increase domestic production and supply chain resilience.

In May, a germanium processor in Belgium and a company in Congo (Kinshasa) entered into a long-term agreement to recover germanium from a mine tailings site in Lubumbashi. The processor in Belgium would assist with the germanium extraction technology at a new recovery plant to be built at the tailings site in exchange for the plant's germanium output. The agreement was facilitated by the Minerals Security Partnership, a collaboration of 14 countries and the European Union to increase investment in responsible critical minerals supply chains.

Global germanium refinery production and recycling data were limited, and available estimates were difficult to verify. China continued to be the leading global producer and exporter of germanium metal in 2024. In August 2023, the Government of China implemented an export licensing program for germanium. China's reported exports of germanium metal for the year through August 2024 decreased by 55% to 16,700 kilograms compared with those in the same period in 2023. These exports were mostly sent to Belgium (33%), Germany (32%), Russia (25%), and Japan (6%). Major germanium producers in China included Yunnan Chihong Germanium and Zinc Co. Ltd. and Yunnan Lincang Xinyuan Germanium Industry Co. Ltd.

Germanium metal and germanium dioxide prices (Europe, minimum 99.999% purity) generally rose between January and September 2024, with the price for germanium metal increasing from $1,550 per kilogram to $2,950 per kilogram and the price for germanium dioxide increasing from $940 per kilogram to $2,125 per kilogram.

World Refinery Production and Reserves:[7] Germanium was known to have been produced or recycled commercially in only a few countries, including the United States, Belgium, Canada, China, Germany, and Russia, with China being the leading producer of germanium. Because most producers do not publicly report germanium production, global production data were limited. Substantial germanium-rich deposits, including tailings sites, that were in operation or in active development were in the United States, China, Congo (Kinshasa), and Russia. However, data were generally not available on the reserves of these deposits.

World Resources:[7] Germanium reserves data were not widely reported at a mine or country level and thus difficult to quantify. The available resources of germanium are associated with certain zinc and lead-zinc-copper sulfide ores and lignite coal deposits.

Substitutes: Silicon or gallium arsenide substitute for germanium in certain electronic applications. Some metallic compounds can be substituted in high-frequency electronics applications and in some light-emitting-diode applications. Chalcogenide glass has been used as a substitute for germanium metal in infrared applications. Antimony and titanium are substitutes for use as polymerization catalysts.

[e]Estimated. NA Not available. — Zero.

[1]Data have been adjusted to exclude low-value shipments. Germanium dioxide data were multiplied by 69% to calculate the germanium content.

[2]Defined as change in total inventory from prior yearend inventory. If negative, increase in inventory. Beginning in 2023, Government stock changes no longer available.

[3]Estimated consumption of germanium contained in metal and germanium dioxide.

[4]Average European price for minimum 99.999% purity. Source: Argus Media Group, Argus Non-Ferrous Markets.

[5]Defined for 2020–22 as imports – exports ± adjustments for Government stock changes. Beginning in 2023, Government stock changes no longer included.

[6]See Appendix B for definitions.

[7]See Appendix C for resource and reserve definitions and information concerning data sources.

GOLD

(Data in metric tons,[1] gold content, unless otherwise specified)

Domestic Production and Use: In 2024, domestic gold mine production was estimated to be 160 tons; the value was estimated to be $12 billion, a 9% increase from the value in 2023. Gold was produced at more than 40 lode mines in 12 States, at several large placer mines in Alaska, and at numerous smaller placer mines (mostly in Alaska and in the Western States). Nevada was the leading gold-producing State, accounting for about 70% of total domestic production, followed by Alaska, which produced about 16% of domestic gold. About 7% of domestic gold was recovered as a byproduct of processing domestic base-metal ores, chiefly copper ores. The top 26 operations yielded about 97% of the mined gold produced in the United States. Commercial-grade gold was produced at approximately 15 refineries. A few dozen companies, out of several thousand companies and artisans, dominated the fabrication of gold into commercial products. U.S. jewelry manufacturing was heavily concentrated in the New York, NY, and Providence, RI, areas, with lesser concentrations in California, Florida, and Texas.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Mine	193	187	173	170	160
Refinery:					
Primary	181	181	181	179	170
Secondary (new and old scrap)	92	92	93	96	90
Imports for consumption[2]	545	192	138	216	150
Exports[2]	297	386	420	252	300
Consumption, reported[3]	187	265	252	253	200
Stocks, Treasury, yearend[4]	8,130	8,130	8,130	8,130	8,130
Price, dollars per troy ounce[5]	1,774	1,801	1,802	1,945	2,400
Employment, mine and mill, number[6]	11,500	11,700	11,500	12,200	12,000
Net import reliance[7] as a percentage of reported consumption	([8])	E	E	E	E

Recycling: In 2024, an estimated 90 tons of new and old scrap was recycled, equivalent to about 45% of reported consumption. The domestic supply of gold from recycling decreased by 6% compared with that in 2023.

Import Sources (2020–23): Ores and concentrates: Canada, 99%; and other, 1%. Dore: Mexico, 38%; Colombia, 20%; Argentina, 12%; Nicaragua, 8%; and other, 22%. Bullion: Switzerland, 35%; Canada, 27%; South Africa, 8%; Australia, 7%; and other, 23%. Total: Switzerland, 24%; Canada, 19%; Mexico, 15%; Colombia, 9%; and other, 33%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Precious metal ore and concentrates:		
Gold content of silver ores	2616.10.0080	0.8 ¢/kg on lead content.
Gold content of other ores	2616.90.0040	1.7 ¢/kg on lead content.
Gold bullion	7108.12.1013	Free.
Gold dore	7108.12.1020	Free.
Gold scrap	7112.91.0100	Free.

Depletion Allowance: 15% (domestic), 14% (foreign).

Government Stockpile: The U.S. Department of the Treasury maintains stocks of gold (see salient statistics above) and the U.S. Department of Defense administers a Governmentwide secondary precious-metals recovery program.

Events, Trends, and Issues: The estimated gold price in 2024 increased by 23% and reached a new record-high annual price compared with the previous record-high annual price in 2023. The Engelhard daily price for gold in 2024 fluctuated with an increasing trend in the first quarter, a decreasing trend into the second quarter, and an increasing trend into the beginning of the fourth quarter.

In 2024, worldwide gold mine production was an estimated 3,300 tons compared with 3,250 tons in 2023. China, Russia, Australia, Canada, and the United States were the leading gold producers, in descending order of production, and together accounted for 41% of estimated global production in 2024.

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GOLD

Estimated global gold consumption, excluding exchange-traded funds and other similar investments, was in jewelry, 45%; central banks and other institutions, 21%; physical bars, 19%; official coins and medals and imitation coins, 7%; electrical and electronics, 6%; and other, 1%. In the first 9 months of 2024, global consumption of gold in physical bars increased by 12%, electronics increased by 12%, other industrial applications were unchanged, dentistry decreased by 5%, jewelry decreased by 7%, and coins and medals decreased by 25% compared with those in the first 9 months of 2023. During the first 9 months of 2024, gold holdings in central banks decreased by 17%, and global investments in gold-based exchange-traded funds and similar investments decreased by 87%. Total global consumption in the first 9 months of 2024 decreased by 3% compared with that in the first 9 months of 2023.[9]

World Mine Production and Reserves: Reserves for Canada, China, Colombia, Indonesia, Kazakhstan, Peru, Russia, and Tanzania were revised based on company and Government reports.

	Mine production		Reserves[10]
	2023	2024[e]	
United States	170	160	3,000
Australia	296	290	[11]12,000
Brazil	71	70	2,400
Burkina Faso	57	60	NA
Canada	198	200	3,200
China	375	380	3,100
Colombia	61	60	700
Ghana	126	130	1,000
Indonesia	[e]100	100	3,600
Kazakhstan	133	130	2,300
Mali	[e]67	70	800
Mexico	127	130	1,400
Peru	100	100	2,500
Russia	313	310	12,000
South Africa	104	100	5,000
Tanzania	55	60	400
Uzbekistan	120	120	1,800
Other countries	777	780	9,200
World total (rounded)	3,250	3,300	64,000

World Resources:[10] An assessment of U.S. gold resources indicated 33,000 tons of gold—15,000 tons in identified and 18,000 tons in undiscovered resources.[12] Nearly one-quarter of the gold in undiscovered resources was estimated to be contained in porphyry copper deposits. The gold resources in the United States, however, are only a small portion of global gold resources.

Substitutes: Base metals clad with gold alloys are widely used to economize on gold in electrical and electronic products and in jewelry; many of these products are continually redesigned to maintain high-utility standards with lower gold content. Generally, palladium, platinum, and silver may substitute for gold.

[e]Estimated. E Net exporter. NA Not available.
[1]One metric ton (1,000 kilograms) = 32,150.7 troy ounces.
[2]Includes refined bullion, dore, ores, concentrates, and precipitates. Excludes waste and scrap, official monetary gold, gold in fabricated items, gold in coins, and net bullion flow (in tons) to market from foreign stocks at the New York Federal Reserve Bank.
[3]Includes gold used in the production of consumer purchased bars, coins, and jewelry. Excludes gold as an investment (except consumer purchased bars and coins). Source: World Gold Council.
[4]Includes gold in the Exchange Stabilization Fund. Stocks were valued at the official price of $42.22 per troy ounce.
[5]Engelhard's average gold price quotation for the year. In 2024, the price was estimated by the U.S. Geological Survey based on data from January through November.
[6]Data from the Mine Safety and Health Administration.
[7]Defined as imports – exports.
[8]Large unreported investor stock purchases preclude calculation of a meaningful net import reliance.
[9]Source: World Gold Council.
[10]See Appendix C for resource and reserve definitions and information concerning data sources.
[11]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 4,600 tons.
[12]Source: U.S. Geological Survey National Mineral Resource Assessment Team, 2000, 1998 assessment of undiscovered deposits of gold, silver, copper, lead, and zinc in the United States: U.S. Geological Survey Circular 1178, 21 p.

GRAPHITE (NATURAL)

(Data in metric tons unless otherwise specified)

Domestic Production and Use: In 2024, natural graphite was not produced in the United States; however, approximately 100 companies, primarily in the Great Lakes and Northeast regions, consumed 52,000 tons valued at an estimated $115 million. The major uses of natural graphite were batteries, brake linings, lubricants, powdered metals, refractory applications, and steelmaking. During 2024, U.S. natural graphite imports were an estimated 60,000 tons, consisting of 87.7% flake and high-purity, 11.8% amorphous, and 0.5% lump and chip graphite.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production, mine	—	—	—	—	—
Imports for consumption	36,000	53,000	89,200	73,500	60,000
Exports	5,920	8,660	9,500	7,780	8,400
Consumption, apparent[1]	30,000	44,300	79,700	65,700	52,000
Price, average unit value of imports, dollars per metric ton at foreign ports:					
Flake	1,340	1,330	1,200	1,080	1,070
Lump and chip (Sri Lanka)	2,940	2,010	2,590	2,380	2,900
Amorphous	567	629	563	607	640
Net import reliance[1] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Refractory brick and linings, alumina-graphite refractories for continuous metal castings, magnesia-graphite refractory brick for basic oxygen and electric arc furnaces, and insulation brick was increasing, with material being recycled into products such as brake linings and thermal insulation. The abundance of graphite in the world market inhibits increased recycling efforts. Information on the quantity and value of recycled graphite is not available.

Import Sources (2020–23): China,[2] 43%; Canada, 13%; Mexico, 13%; Mozambique, 13%; and other, 18%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Crystalline flake (not including flake dust)	2504.10.1000	Free.
Powder	2504.10.5000	Free.
Other	2504.90.0000	Free.

Depletion Allowance: Lump and amorphous, 22% (domestic) and flake, 14% (domestic); 14% (foreign).

Government Stockpile: None.

Events, Trends, and Issues: U.S. natural graphite imports, by tonnage, were 20% lower during the first 8 months of 2024 compared with those in the same period in 2023. Apparent consumption decreased by an estimated 21%, attributed to decreased demand from the battery industry and increased availability of synthetic graphite battery material from China. Prices for fine flake graphite have decreased by 20% through the first 10 months of 2024.[3] Prices for medium flake and larger have increased by about 10% through the first 10 months of 2024.

In 2024, China was the world's leading graphite producer, producing an estimated 78% of total world production. Approximately 15% of graphite produced in China was amorphous and about 85% was flake. During the first 8 months of the year, China exported 38,200 tons of flake graphite concentrate, 25% less than the 50,700 tons exported in the same period in 2023. Exports during the first 2 months of 2024 were 78% less compared with those in 2023, but 4% less from March to October. During the first 8 months of 2024, China exported 25,500 tons of spherical graphite, 28% less than the 35,600 tons exported in 2023. Exports during the first 2 months of 2024 were 65% less compared with those in 2023 and were 19% less in the next 6 months. The decrease early in the year was likely due to licensing delays related to the export restrictions that took effect in December 2023. The leading recipients of natural flake graphite from China in 2024 were the Republic of Korea (21%), Japan (20%), Germany (17%), and the United States (6%). The leading recipients of spherical graphite from China in the first 8 months of 2024 were the Republic of Korea (49%), Japan (29%), and the United States (19%).

In 2024, three companies were awarded grants through U.S. Government programs. A company was awarded $8.3 million through the Defense Production Act, Title III, for the development of a natural flake graphite mine in Canada. The other two projects were awarded $125 million each, through the Bipartisan Infrastructure Law of 2021. One was for the development of battery-grade graphite recycling facilities in Kentucky and Louisiana, and the other was to develop a coated spherical graphite production facility in Alabama.

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GRAPHITE (NATURAL)

In May, the U.S. Department of the Treasury announced temporary extensions for rules regarding graphite imports from China. The rules had originally barred graphite from China, among other countries, for the electric vehicle tax credit eligibility. The temporary graphite exemption lasts until 2027. In May, the President announced an increase of the tariff rate on natural graphite sourced from China from 0% to 25% beginning in 2026.

Five companies were exploring or developing graphite-mining projects in the United States: two in Alabama, one in Alaska, one in Montana, and one in New York. In October, a company in Alabama released the results of a preliminary economic assessment. The company planned to produce 47,000 tons per year of graphite concentrate.

In February, a company began commercial production of spherical graphite in Vidalia, LA. The facility had an initial capacity of 11,300 tons per year. The company also continued work on a definitive feasibility study to expand capacity to 45,000 tons per year. An additional company continued construction of a spherical graphite facility in Kellyton, AL. Five other companies were developing or considering spherical graphite facilities in the United States.

Two flake graphite mines, located in Brazil and Tanzania, began production in 2024. Phase 1 production capacity at the Santa Cruz Mine in Brazil was 12,000 tons per year of graphite concentrate, potentially expanding up to 50,000 tons per year in later phases. At the Lindi Jumbo Mine in Tanzania, capacity was 40,000 tons per year of graphite concentrate. A Russian company continued to construct a graphite mine in Russia, with production scheduled to begin in late 2024. Capacity was an estimated 40,000 tons per year of flake graphite concentrate.

World Mine Production and Reserves: Reserves for Canada, China, Madagascar, and Vietnam were revised based on company and Government reports.

	Mine production		Reserves[4]
	2023	2024[e]	
United States	—	—	([5])
Austria	500	500	([5])
Brazil	66,300	68,000	74,000,000
Canada	5,470	20,000	5,900,000
China	1,210,000	1,270,000	81,000,000
Germany	180	170	([5])
India	25,600	27,800	8,600,000
Korea, North	[e]8,100	8,100	2,000,000
Korea, Republic of	9,620	9,600	1,800,000
Madagascar	[e]63,000	89,000	27,000,000
Mexico	1,300	900	3,100,000
Mozambique	[e]98,000	75,000	25,000,000
Norway	6,480	7,000	600,000
Russia	[e]15,000	20,000	14,000,000
Sri Lanka	3,000	3,300	1,500,000
Tanzania	[e]13,200	25,000	18,000,000
Turkey	2,800	3,100	6,900,000
Ukraine	1,670	1,200	([5])
Vietnam	2,500	2,000	9,700,000
World total (rounded)	1,530,000	1,600,000	290,000,000

World Resources:[4] Domestic resources of graphite are relatively small, but the rest of the world's resources exceed 800 million tons of recoverable graphite.

Substitutes: Synthetic graphite powder, scrap from discarded machined shapes, and calcined petroleum coke compete for use in iron and steel production. Synthetic graphite powder and secondary synthetic graphite from machining graphite shapes compete for use in battery applications. Finely ground coke with olivine is a potential competitor in foundry-facing applications. Molybdenum disulfide competes as a dry lubricant but is more sensitive to oxidizing conditions.

[e]Estimated. — Zero.
[1]Defined as imports – exports.
[2]Includes Hong Kong.
[3]Source: Fastmarkets IM.
[4]See Appendix C for resource and reserve definitions and information concerning data sources.
[5]Included in "World total."

GYPSUM

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: In 2024, domestic production of crude gypsum was estimated to be 22 million tons with a value of about $290 million. The leading crude gypsum-producing States were estimated to be California, Iowa, Kansas, Nevada, Oklahoma, and Texas. Overall, 47 companies produced or processed gypsum in the United States at 45 mines in 15 States. The majority of domestic consumption, which totaled approximately 44 million tons, was used by agriculture, cement production, and manufacturers of wallboard and plaster products. Small quantities of high-purity gypsum, used in a wide range of industrial processes, accounted for the remaining tonnage. At the beginning of 2024, the production capacity of gypsum panel manufacturing in the United States was about 34 billion square feet[1] per year. Total wallboard sales in 2024 were estimated to be 28 billion square feet.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production:					
Crude	21,300	20,800	22,300	21,500	22,000
Synthetic[2]	14,100	15,900	15,400	15,400	15,000
Calcined[3]	17,900	18,600	18,700	18,300	19,000
Wallboard products sold, million square feet[1]	26,200	27,300	28,200	27,000	28,000
Imports, crude, including anhydrite	6,030	6,520	6,870	7,770	7,400
Exports, crude, not ground or calcined	32	42	39	44	45
Consumption, apparent[4]	41,400	43,200	44,600	44,600	44,000
Price, average, dollars per metric ton:					
Crude, free on board (f.o.b.) mine	8.6	11	11	12	13
Calcined, f.o.b. plant	35	42	50	60	63
Employment, mine and calcining plant, number[e]	4,500	4,500	4,500	4,500	4,500
Net import reliance[5] as a percentage of apparent consumption	14	15	15	17	17

Recycling: Approximately 700,000 tons per year of gypsum scrap that was generated by wallboard manufacturing was recycled onsite. The recycling of wallboard from new construction and demolition sources also took place, although those amounts are unknown. Recycled gypsum was used primarily for agricultural purposes and feedstock for the manufacture of new wallboard. Other potential markets for recycled gypsum include athletic-field marking, cement production (as a stucco additive), grease absorption, sludge drying, and water treatment.

Import Sources (2020–23): Spain, 36%; Mexico, 31%; Canada, 29%; and Turkey, 4%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Gypsum, anhydrite	2520.10.0000	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: U.S. crude gypsum production was estimated to have increased to 22 million tons compared with 21.5 million tons in 2023 and apparent consumption was an estimated 44 million tons in 2024 compared with 44.6 million tons in 2023. Gypsum imports for consumption decreased by an estimated 5% compared with those in 2023. Exports, although very low compared with imports, increased slightly.

Demand for gypsum depends principally on construction industry activity, particularly in the United States, where most gypsum consumed is used for agriculture, building plasters, the manufacture of portland cement, and wallboard products. According to the U.S. Census Bureau, housing starts through September 2024 were at a seasonally adjusted annual rate of 1,354,000 compared with 1,363,000 starts from January through September 2023.

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GYPSUM

Synthetic gypsum consumption, after more than 20 years of large annual growth rates, has remained somewhat static in recent years. This is largely a result of an increase in natural gas electrical generation and a decrease in coal-fired electrical generation. Increased use of wallboard in Asia, coupled with new gypsum product plants, spurred increased production in the region. As wallboard becomes more widely used, worldwide gypsum production is expected to increase.

World Mine Production and Reserves: Reserves for China, France, and Iran were revised based on Government reports.

	Mine production[e]		Reserves[6]
	2023	2024	
United States	[7]21,500	22,000	700,000
Algeria	2,500	2,500	NA
Brazil	[7]3,930	3,600	450,000
Canada	2,400	2,400	450,000
China	12,000	12,000	1,800,000
France	2,400	2,400	300,000
Germany	4,900	4,900	NA
India	4,300	4,300	37,000
Iran	16,000	16,000	750,000
Japan	4,300	4,300	NA
Mexico	5,400	5,400	NA
Oman	[7]13,900	14,000	NA
Pakistan	2,100	2,100	760,000
Russia	4,100	4,100	NA
Saudi Arabia	3,800	3,800	NA
Spain	11,000	11,000	NA
Thailand	9,800	9,800	910,000
Turkey	[7]10,300	10,000	200,000
Uzbekistan	2,000	2,000	NA
Other countries	20,000	23,000	NA
World total (rounded)	157,000	160,000	Large

World Resources:[6] Reserves are large in major producing countries, but data for most are not available. Domestic gypsum resources are adequate but unevenly distributed. Large imports from Canada augment domestic supplies for wallboard manufacturing in the United States, particularly in the eastern and southern coastal regions. Imports from Mexico supplement domestic supplies for wallboard manufacturing along portions of the United States west coast. Large gypsum deposits occur in the Great Lakes region, the midcontinent region, and several Western States. Foreign resources are large and widely distributed; gypsum production was estimated for 78 countries in 2024.

Substitutes: In such applications as stucco and plaster, cement and lime may be substituted for gypsum; brick, glass, metallic or plastic panels, and wood may be substituted for wallboard. Gypsum has no practical substitute in the manufacturing of portland cement. Synthetic gypsum generated by various industrial processes, including flue gas desulfurization of smokestack emissions, is very important as a substitute for mined gypsum in wallboard manufacturing, cement production, and agricultural applications (in descending order by tonnage). In 2024, synthetic gypsum was estimated to account for about 34% of the total domestic gypsum supply.

[e]Estimated. NA Not available.

[1]The standard unit used in the U.S. wallboard industry is square feet; multiply square feet by 0.0929 to convert to square meters. Source: The Gypsum Association.

[2]Synthetic gypsum used; the majority of these data were obtained from the American Coal Ash Association.

[3]From domestic crude and synthetic gypsum.

[4]Defined as crude production + synthetic used + imports – exports.

[5]Defined as imports – exports.

[6]See Appendix C for resource and reserve definitions and information concerning data sources.

[7]Reported.

HELIUM

(Data in million cubic meters, helium gas[1] content, unless otherwise specified)

Domestic Production and Use: In 2024, sales of Grade-A helium (99.997% helium or greater) and gaseous helium (generally greater than 98% helium) were an estimated 81 million cubic meters (2.9 billion cubic feet) valued at an estimated $1.1 billion. Five plants (three in Texas and two in Kansas) extracted helium from natural gas and produced crude helium that generally ranged from 50% to 80% helium. Twelve plants (three in New Mexico, two each in Arizona, Colorado, and Kansas, and one each in Montana, Oklahoma, and Utah) produced gaseous helium. Four plants (two in Colorado and one each in Texas and Wyoming) extracted helium from natural gas and produced Grade-A helium. Four plants (three in Kansas and one in Oklahoma) accepted crude helium from other producers and the Bureau of Land Management (BLM) pipeline and purified it to Grade-A helium. In 2024, estimated domestic apparent consumption of Grade-A and gaseous helium was 56 million cubic meters (2.0 billion cubic feet), and it was used for, in decreasing quantity of use, analytical, engineering, lab, science, and specialty gases (22%); lifting gas (18%); magnetic resonance imaging (17%); controlled atmospheres, fiber optics, and semiconductors (15%); welding (8%); aerospace, pressuring, and purging (7%); leak detection (5%); diving (5%); and various other minor applications (3%).

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Helium extracted from natural gas[2]	72	69	65	64	68
Withdrawn from storage[3]	10	7	12	18	13
Grade-A and gaseous helium sales	82	76	77	81	81
Imports for consumption	7	8	6	8	12
Exports	35	33	32	33	42
Consumption, apparent[4]	53	51	51	56	[5]56
Net import reliance[6] as a percentage of apparent consumption	E	E	E	E	E

The estimated base price[7] for Grade-A helium was about $14 per cubic meter ($390 per thousand cubic feet) in 2024, with producers posting surcharges to this price.

Recycling: In the United States, helium used in large-volume applications is seldom recycled. Some low-volume or liquid boil-off recovery systems are used. In the rest of the world, helium recycling is more common.

Import Sources (2020–23): Qatar, 40%; Canada, 36%; Algeria, 10%; Russia, 4%; and other, 10%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Helium	2804.29.0010	3.7% ad valorem.

Depletion Allowance: Allowances are applicable to natural gas from which helium is extracted, but no allowance is granted directly to helium.

Government Stockpile:[8] The Federal Helium System included operations of the Cliffside helium facilities, the Cliffside Field helium storage reservoir, and the Government's crude helium pipeline system. The Crude Helium Enrichment Unit (CHEU) was privately owned and leased to the BLM. The Helium Stewardship Act of 2013 (HSA) mandated the privatization of the Federal Helium System. The BLM was directed to sell at auction the Federal Conservation Helium stored in Bush Dome at the Cliffside Field. The last auction was completed in summer 2018. In December 2022, the management of the Federal Helium System was transferred from the BLM to the General Services Administration to dispose of all assets. On January 25, 2024, the Federal Helium System assets were sold in two lots. Lot 1 included approximately 28 million cubic meters (1.0 billion cubic feet) of Federally owned crude helium. Lot 2 included the Federal Helium System and approximately 22 million cubic meters (800 million cubic feet) of crude helium. Both lots were sold to one company and were transferred on June 27, 2024.

Events, Trends, and Issues: In 2024, Grade-A and gaseous helium sales were unchanged, whereas helium extracted from natural gas increased by 7% compared with those in 2023. The increase in helium extracted from natural gas was mainly due to new operations that came online in 2023 and 2024 but was offset by a 26% decrease in helium withdrawn from the Cliffside Field compared with that in 2023. Four new helium operations (one each in Colorado, Montana, New Mexico, and Texas) began producing helium in the United States.

The CHEU, which is the helium purification unit at the Cliffside Field, was not part of the sale of the Federal Helium System. The CHEU is owned by a private entity and was previously leased to the BLM. The lease of the CHEU ended on August 11, 2024, and a new lease agreement was not completed by the expiration date. The District Court of Amarillo, TX, allowed the new owner of the Cliffside Field to operate the equipment and keep the domestic supply available while negotiations continued. An agreement had not been reached by the end of year.

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HELIUM

Estimated total world helium production increased by 4% compared with that in 2023. Three new helium facilities began operations in Canada, and imports of helium from Canada increased in 2024. Multiple companies explored for and developed helium deposits throughout the world. Some of these helium deposits are nonhydrocarbon sourced. On June 25, 2024, the European Union adopted a sanctions package, effective September 26, 2024, that imposed an import ban on helium from Russia.

World Production and Reserves: Reserves for the United States were revised based on Government reports.

	Production		Reserves[9]
	2023	2024[e]	
United States (extracted from natural gas)	64	68	8,500
United States (from the Cliffside Field)	18	13	50
Algeria	[e]9	11	[e]1,800
Australia	[e]1	—	NA
Canada	5	6	NA
China	2	3	NA
Poland	3	3	24
Qatar	[e]66	64	[e]Large
Russia	[e]8	17	[e]1,700
South Africa	—	([10])	NA
World total (rounded)	[e]176	180	NA

World Resources:[9] The U.S. Geological Survey (USGS) and the BLM coordinated efforts to complete a national helium gas assessment, which was published by the USGS in fall 2021.[11] The mean volume of recoverable helium within the known geologic natural gas reservoirs in the United States was estimated to be 8,490 million cubic meters (306 billion cubic feet). This does not include the remaining 51.5 million cubic meters (1.86 billion cubic feet) in the Federal helium inventory. The estimated mean for the Midcontinent region was 4,330 million cubic meters (156 billion cubic feet); the Rocky Mountain region, 4,110 million cubic meters (148 billion cubic feet); the North Central region, 52.7 million cubic meters (1.9 billion cubic feet); the Gulf Coast region, 12.5 million cubic meters (0.45 billion cubic feet); and the Alaska region, 1.11 million cubic meters (0.04 billion cubic feet).

Helium resources of the world, exclusive of the United States, were estimated to be about 31.3 billion cubic meters (1.13 trillion cubic feet). The locations and volumes of the major deposits, in billion cubic meters, are Qatar, 10.1; Algeria, 8.2; Russia, 6.8; Canada, 2.0; and China, 1.1.

Substitutes: Nothing substitutes for helium in cryogenic applications if temperatures below −429 degrees Fahrenheit are required. Superconductors, including those in magnetic resonance imaging scanners, are being developed to operate at higher temperatures using nitrogen instead of helium as a coolant. Hydrogen can be substituted for helium in some lighter-than-air applications in which the flammable nature of hydrogen is not objectionable. Argon can be substituted for helium in welding. Hydrogen can be used as a substitute for helium in deep-sea diving applications.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Measured at 101.325 kilopascals absolute (14.696 pounds per square inch [psia]) and 15 degrees Celsius (°C) [59 degrees Fahrenheit (°F)]; 27.737 cubic meters of helium = 1,000 cubic feet of helium at 101.325 kilopascals absolute (14.696 psia) and 21.1 °C (70 °F).
[2]As Grade-A, gaseous, or crude helium.
[3]Extracted from natural gas in prior years.
[4]Grade-A and gaseous helium. Defined as sales + imports – exports.
[5]Consumption was estimated by the U.S. Geological Survey for 2024 because the export data reported by the U.S. Census Bureau were unusually high and may have contained misclassified items.
[6]Defined as imports – exports.
[7]Not including free on board (f.o.b.) or other costs associated with transporting helium from the producer to the buyer.
[8]See Appendix B for definitions.
[9]See Appendix C for resource and reserve definitions and information concerning data sources.
[10]Less than ½ unit.
[11]Brennan, S.T., Rivera, J.L., Varela, B.A., and Park, A.J., 2021, National assessment of helium resource within known natural gas reservoirs: U.S. Geological Survey Scientific Investigations Report 2021–5085, 5 p., https://doi.org/10.3133/sir20215085.

INDIUM

(Data in metric tons unless otherwise specified)

Domestic Production and Use: Indium was not recovered from ores in the United States in 2024. Several companies produced indium products—including alloys, compounds, high-purity metal, and solders—from imported indium metal. Production of indium tin oxide (ITO) continued to account for most global indium consumption. ITO thin-film coatings were primarily used for electrically conductive purposes in a variety of flat-panel displays—most commonly liquid crystal displays (LCDs). Other indium end uses included alloys and solders, compounds, electrical components and semiconductors, and research. Estimated domestic consumption of refined indium was 250 tons in 2024 and was based on the annual estimated import quantity. There were no readily available recycling or end-use data available for indium. The estimated value of refined indium consumed domestically in 2024, based on the average U.S. warehouse price, was about $85 million.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, refinery	—	—	—	—	—
Imports for consumption	115	158	202	219	250
Exports	NA	NA	NA	NA	NA
Consumption, estimated[1]	115	158	202	219	250
Price, annual average, dollars per kilogram:					
New York dealer[2]	395	NA	NA	NA	NA
U.S. warehouse, free on board[3]	161	223	250	244	340
Rotterdam, duties unpaid[4]	158	217	257	238	300
Net import reliance[5] as a percentage of estimated consumption	100	100	100	100	100

Recycling: Indium is most commonly recovered from ITO scrap in Japan and the Republic of Korea. Indium-containing scrap was recycled domestically; however, data on the quantity of indium recovered from scrap were not available.

Import Sources (2020–23): Republic of Korea, 29%; Japan 18%; Canada, 14%; Belgium, 9%; and other, 30%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Unwrought indium, including powders	8112.92.3000	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: In 2024, the estimated annual average U.S. warehouse price (free on board) was $340 per kilogram, 42% more than the reported average price in 2023. The U.S. price, as reported by Argus Media Group, Argus Non-Ferrous Markets, began the year at $265 per kilogram until April when the price started to increase drastically as United States prices followed price increases on the Chinese Changzhou ZonglianJin platform. By June, the price had peaked at $420 per kilogram.

In September, the Office of the United States Trade Representative announced final tariff modifications after completing its review of the actions imposed under section 301(b) of the Trade Act of 1974 (19 U.S.C. 2411, as amended): China's acts, policies, and practices related to technology transfer, intellectual property, and innovation. Additional categories of goods from China were subject to tariffs including a 25% ad valorem tariff on critical minerals, which included indium. Over the past 4 years, the United States has, on average, imported 8% of its indium from China. As of September 2024, 25% of United States indium imports came from China.

China is the leading global producer of Indium, accounting for 70% of the world total. China is also the leading exporter of indium globally and exported 347 tons of indium in the first 9 months of 2024, about the same as that in the same period in 2023. Exports were primarily sent to the Republic of Korea, 74%; Malaysia, 10%; and the United States, 10%. China imported 180 tons of indium over the same time period.

As of July, a zinc-copper-silver-indium project in Utah was fully permitted for the construction of an exploration shaft and open pit mine. In August, an indium-phosphide-wafer fabrication facility, located in Alhambra, CA, resumed production after it was acquired by a U.S.-based photonic devices manufacturer.

Kazakhstan plans to open access to previously classified deposits of indium and other rare metals in order to attract foreign investment as it did in 2021 with lithium.

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INDIUM

Fifth-generation (5G) technologies continued to increase demand for indium. Indium phosphide (InP)-based substrates are used in 5G fiber-optic telecommunications networks where InP lasers and receivers send data through fiber-optic lines, which allow for lower latency, reduced signal loss, and faster speeds.

Artificial intelligence was expected to increase demand for specialized chip materials, including those made of InP, that allow for more advanced computation. A domestic semiconductor substrate company indicated that its second quarter revenue from InP increased 67% year on year. Indium, as ITO, is used as a coating on data center fibers and cables to increase signal transmission and reduce loss. InP is also used in high-speed photodetectors and laser diodes for optical communications. Additionally, some electrical components in data centers use indium-based solder alloys.

Since the CHIPS and Science Act was signed into law in 2022, the U.S. Department of Commerce announced as of October 2024 preliminary agreements with 20 companies for 32 semiconductor manufacturing projects in 20 States. In total, these projects have received almost $34 billion of the available $39 billion in direct funding and almost $29 billion in loans. The Department of Commerce planned to allocate the remaining funds to CHIPS and Science Act grantees by the end of 2024.

World Refinery Production and Capacity:

	Refinery production		Refinery capacity
	2023	2024[e]	2024[e]
United States	—	—	—
Belgium	19	10	50
Canada	40	35	70
China	690	760	1,100
France	21	21	70
Japan	65	60	70
Korea, Republic of	180	180	310
Peru	—	—	50
Russia	5	10	15
Uzbekistan	1	1	1
World total (rounded)	1,020	1,080	1,800

World Resources:[7] Indium is most commonly recovered from the zinc-sulfide ore mineral sphalerite. The indium content of zinc deposits from which it is recovered ranges from less than 1 part per million to 100 parts per million. Although the geochemical properties of indium are such that it occurs in trace amounts in other base-metal sulfides—particularly chalcopyrite and stannite—indium recovery from most deposits of these minerals was not economic.

Substitutes: Antimony tin oxide coatings have been developed as an alternative to ITO coatings in LCDs and have been successfully annealed to LCD glass; carbon nanotube coatings have been developed as an alternative to ITO coatings in flexible displays, solar cells, and touch screens; poly (3,4-ethylene dioxythiophene) (PEDOT) has also been developed as a substitute for ITO in flexible displays and organic light-emitting diodes; and copper or silver nanowires have been explored as a substitute for ITO in touch screens. Graphene has been developed to replace ITO electrodes in solar cells and also has been explored as a replacement for ITO in flexible touch screens. Researchers have developed a more adhesive zinc oxide nanopowder to potentially replace ITO in LCDs. Hafnium can replace indium in nuclear reactor control rod alloys.

[e]Estimated. NA Not available. — Zero.
[1]Estimated to equal imports.
[2]Price is based on 99.99%-minimum-purity indium, delivered duty paid by U.S. buyers, in minimum lots of 50 kilograms. Source: S&P Global Platts Metals Week; price was discontinued as of September 11, 2020.
[3]Price is based on 99.99%-minimum-purity indium, free on board U.S. warehouse. Source: Argus Media Group, Argus Non-Ferrous Markets.
[4]Price is based on 99.99%-minimum-purity indium, duties unpaid in warehouse (Rotterdam). Source: Argus Media Group, Argus Non-Ferrous Markets.
[5]Defined as imports – exports.
[6]Refinery production data for indium were limited or unavailable for most countries. Estimates were derived from trade data, production capacity, and (or) changes in related lead and zinc smelter production.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.

IODINE

(Data in metric tons, elemental iodine, unless otherwise specified)

Domestic Production and Use: Iodine was produced from brines in 2024 by three companies operating in Oklahoma. U.S. iodine production in 2024 was withheld to avoid disclosing company proprietary data but was estimated to have increased from that in 2023. The annual average cost, insurance, and freight unit value of iodine imports in 2024 was estimated to be $59 per kilogram, about 4% less than that in 2023.

Because domestic and imported iodine was used by downstream manufacturers to produce many intermediate iodine compounds, it was difficult to establish an accurate end-use pattern. Crude iodine and inorganic iodine compounds were estimated to account for almost 80% of domestic iodine consumption in 2024, and organic iodine compounds were estimated to account for about 20%. Worldwide, the leading uses of iodine and its compounds were X-ray contrast media (XRCM), pharmaceuticals, liquid crystal displays (LCDs), iodophors, animal feed, and fluorochemicals, in descending order of quantity consumed. Other applications of iodine included biocides, food supplements, and nylon.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production	W	W	W	W	W
Imports for consumption	4,570	4,120	4,270	2,860	3,300
Exports	1,130	1,280	1,140	1,410	1,200
Consumption:					
Apparent[1]	W	W	W	W	W
Reported	3,750	3,720	3,330	2,580	2,900
Price, crude iodine, average unit value of imports (cost, insurance, and freight), dollars per kilogram	31.57	32.72	45.81	61.55	59.00
Employment, number[e]	60	60	60	60	60
Net import reliance[2] as a percentage of apparent consumption	>50	>50	>50	<50	>50

Recycling: Small amounts of iodine were recycled.

Import Sources (2020–23): Chile, 90%; Japan, 9%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Iodine, crude	2801.20.0000	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

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IODINE

Events, Trends, and Issues: According to industry publications, spot prices for iodine crystal averaged about $69 per kilogram during the first 9 months of 2024. This was about 3% less than the 2023 annual average of $71.48 per kilogram. Though average iodine prices were lower in 2024 compared with average prices in 2023, iodine sales increased, reflecting strong global demand in 2024.

One U.S. producer opened a seventh iodine production plant in the second half of 2024.The new plant was expected to add an additional 100 to 150 metric tons per year of crystalline iodine to the company's annual production. The company also signed an agreement for an eighth plant that was expected to become operational in 2025.

As in recent years, Chile was the world's leading producer of iodine, followed by Japan and the United States. Excluding production in the United States, Chile accounted for about two-thirds of world production in 2024. Most of the world's iodine supply comes from three areas: the Chilean desert nitrate mines, the gasfields and oilfields in Japan, and the iodine-rich brine wells in northwestern Oklahoma.

World Mine Production and Reserves: China and Uzbekistan also produce crude iodine, but output is not officially reported, and available information was inadequate to make reliable estimates of output.

	Mine production[e]		Reserves[3]
	2023	2024	
United States	W	W	250,000
Azerbaijan	200	210	170,000
Chile	21,000	22,000	610,000
Indonesia	30	30	NA
Iran	700	700	40,000
Japan	9,900	9,300	4,900,000
Russia	3	3	120,000
Turkmenistan	770	770	70,000
World total (rounded)	[4]32,600	[4]33,000	6,200,000

World Resources:[3] Seawater contains 0.06 part per million iodine, and the oceans are estimated to contain approximately 90 billion tons of iodine. Seaweeds of the Laminaria family are able to extract and accumulate up to 0.45% iodine on a dry basis. Although not as economical as the production of iodine as a byproduct of gas, nitrates, and oil, the seaweed industry represented a major source of iodine prior to 1959 and remains a large resource.

Substitutes: No comparable substitutes exist for iodine in many of its principal applications, such as in animal feed, catalytic, nutritional, pharmaceutical, and photographic uses. Bromine and chlorine could be substituted for iodine in biocide, colorant, and ink, although they are usually considered less desirable than iodine. Antibiotics can be used as a substitute for iodine biocides.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Defined as production + imports – exports.
[2]Defined as imports – exports.
[3]See Appendix C for resource and reserve definitions and information concerning data sources.
[4]Excludes U.S. production.

IRON AND STEEL[1]

(Data in million metric tons, metal, unless otherwise specified)

Domestic Production and Use: The U.S. iron and steel industry produced 81 million tons of raw steel in 2024 with an estimated sales value of about $120 billion, a 10% decrease from $132 billion in 2023. Pig iron and raw steel were produced by two companies operating integrated steel mills in 12 locations. Raw steel from electric arc furnaces was produced by 49 companies at 104 minimills. Combined raw steel production capacity was about 107 million tons per year. Indiana accounted for an estimated 25% of total raw steel production, followed by Ohio, 12%; Texas, 6%; and Pennsylvania, 5%; no other individual State accounted for more than 4% of total domestic raw steel production. Construction accounted for an estimated 28% of net shipments by market classification, followed by steel service centers and distributors, 23%; automotive, 15%; steel for converting and processing, 9%; and appliances, machinery, and oil and gas, 3% each; all other applications accounted for 16% of net shipments.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Pig iron production	18.3	22.2	20.0	22.5	22
Raw steel production	72.7	85.8	80.5	81.4	81
Distribution of raw steel production, percent:					
Basic oxygen furnaces	29	30	29	28	28
Electric arc furnaces	71	70	71	72	72
Continuously cast steel, percent	99.8	99.8	99.7	99.7	99.7
Shipments, steel mill products	73.5	85.9	81.2	81.0	78
Imports, steel mill products:					
Finished	14.6	20.6	22.9	19.7	20
Semifinished	5.3	7.9	5.1	5.9	6
Total	20.0	28.5	28.0	25.6	26
Exports, steel mill products:					
Finished	6.0	7.4	7.5	7.9	8
Semifinished	0.1	0.1	0.1	0.3	0.3
Total	6.1	7.5	7.6	8.2	8
Stocks, service centers, yearend[2]	5.8	5.8	6.7	6.5	7.0
Consumption, apparent (steel mill products)[3]	82.9	98.9	96.8	93.0	93
Producer price index for steel mill products (1982=100)[4]	184	351	382	320	290
Employment, average, number:					
Iron and steel mills[4]	83,200	78,300	80,800	84,000	81,000
Steel product manufacturing[4]	54,900	52,700	55,400	58,500	56,000
Net import reliance[5] as a percentage of apparent consumption	12	13	17	13	13

Recycling: See the Iron and Steel Scrap and the Iron and Steel Slag chapters.

Import Sources (2020–23): Canada, 23%; Mexico, 16%; Brazil, 13%; Republic of Korea, 9%; and other, 39%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Carbon steel:		
Semifinished	7207.00.0000	Free.
Flat, hot-rolled	7208.00.0000	Free.
Flat, cold-rolled	7209.00.0000	Free.
Galvanized	7210.00.0000	Free.
Bars and rods, hot-rolled	7213.00.0000	Free.
Structural shapes	7216.00.0000	Free.
Stainless steel:		
Semifinished	7218.00.0000	Free.
Flat-rolled sheets	7219.00.0000	Free.
Bars and rods	7222.00.0000	Free.

Depletion Allowance: Not applicable.

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IRON AND STEEL

Government Stockpile:[6]

	FY 2024		FY 2025	
Material	**Potential acquisitions**	**Potential disposals**	**Potential acquisitions**	**Potential disposals**
Grain-oriented electrical steel[7]	3,200	—	3,200	—

Events, Trends, and Issues: In January 2024, one domestic steel company was selected by the U.S. Department of Energy for up to $575 million in funding towards decarbonization efforts by replacing furnaces with a direct-reduced iron plant and electric arc melting furnaces in Ohio and with induction slab reheat furnaces in Pennsylvania. In April, another domestic steel company was awarded $281 million in grants from the U.S. Internal Revenue Service towards the construction of a 150,000-ton-per-year plant in Calvert, AL, that would produce non-grain-oriented electrical steel. Electrical steel was identified as a critical material by the U.S. Department of Energy in its 2023 Critical Materials Assessment owing to its role in the performance and efficiency improvements of electric motors used to power electric and hybrid vehicles. In May, one company headquartered in Tokyo, Japan, anticipated that its purchase of a major domestic steel company would be delayed until the end of 2024 following additional requests for documentation from the United States Department of Justice. The World Steel Association[8] estimated that U.S. production of finished steel products would decrease by 1.5% and global finished steel consumption would decrease by 0.9% in 2024. End-use consumption of finished steel products was expected to decrease owing to issues affecting consumer demand, including geopolitical uncertainties, inflation, and monetary tightening. Effects of economic conditions in major developed nations, with the exception of India, included slowdowns in the automotive, construction, and manufacturing sectors.

World Production:

	Pig iron		Raw steel	
	2023	**2024[e]**	**2023**	**2024[e]**
United States	22.5	22	81.4	81
Brazil	26	27	32	34
Canada	6	6	12	12
China	871	840	1,020	990
Germany	24	23	35	35
India	86	93	141	150
Iran	4	4	31	33
Italy	3	3	21	21
Japan	63	62	87	85
Korea, Republic of	45	44	67	64
Mexico	1	1	16	16
Russia	55	54	76	75
Taiwan	12	12	19	19
Turkey	9	8	34	32
Ukraine	6	6	6	6
Vietnam	13	13	19	19
Other countries	61	67	188	200
World total (rounded)	1,310	1,300	1,890	1,900

World Resources: Not applicable. See the Iron Ore chapter for steelmaking raw-material resources.

Substitutes: Iron is the least expensive and most widely used metal. In most applications, iron and steel compete either with less expensive nonmetallic materials or with more expensive materials that have a performance advantage. Iron and steel compete with lighter materials, such as aluminum and plastics in the automotive industry; aluminum, concrete, and wood in construction; and aluminum, glass, paper, and plastics in containers.

[e]Estimated. — Zero.
[1]U.S. production and shipments data source is the American Iron and Steel Institute; see also the Iron and Steel Scrap and the Iron Ore chapters.
[2]Steel mill products. Source: Metals Service Center Institute, September 2024.
[3]Defined as steel mill product shipments + imports of finished steel mill products – exports of steel mill products ± adjustments for stock changes.
[4]Source: U.S. Department of Labor, Bureau of Labor Statistics, North American Industry Classification System Code 331100 and 332100.
[5]Defined as imports of finished steel mill products – total exports ± adjustments for industry stock changes.
[6]See Appendix B for definitions.
[7]Metric tons.
[8]Source: World Steel Association, 2024, worldsteel short range outlook October 2024: Brussels, Belgium, World Steel Association press release, October 14, 3 p.

IRON AND STEEL SCRAP[1]

(Data in million metric tons, metal, unless otherwise specified)

Domestic Production and Use: In 2024, the total value of domestic purchases of iron and steel scrap (home scrap and net receipts of ferrous scrap by all domestic consumers from brokers, dealers, and other outside sources) was an estimated $24 billion, a 4% decrease from $24.7 billion in 2023. Manufacturers of pig iron, raw steel, and steel castings accounted for almost all scrap consumption by the domestic steel industry, using scrap together with pig iron and direct-reduced iron to produce steel products for the appliance, construction, container, machinery, oil and gas, transportation, and various other consumer industries. The ferrous castings industry consumed most of the remaining scrap to produce cast iron and steel products. Relatively small quantities of steel scrap were used for producing ferroalloys, for the precipitation of copper, and by the chemical industry; these uses collectively totaled less than 1 million tons.

U.S. apparent consumption of iron and steel scrap was an estimated 63 million tons in 2024 compared with 62 million tons in 2023. In 2024, estimated raw steel production, the leading use for iron and steel scrap, was 81 million tons compared with 81.4 million tons in 2023, and net shipments of steel mill products in 2024 were an estimated 78 million tons, compared with 81.0 million tons in 2023.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production:					
Home scrap	8.1	7.4	8.1	7.2	8.6
Net receipts	61	69	65	66	65
Imports for consumption	4.6	5.3	4.7	5.1	4.7
Exports	17	18	18	16	15
Consumption:					
Reported	56	64	61	62	63
Apparent[2]	56	63	61	62	63
Price, average, delivered, No. 1 heavy melting composite price, dollars per metric ton[3]	231.34	424.36	387.85	338.63	325.00
Stocks, consumer, yearend	3.8	4.4	3.9	4.2	4.2
Employment, foundries, number[4]	106,000	101,000	105,000	107,000	108,000
Net import reliance[5] as a percentage of reported consumption	E	E	E	E	E

Recycling: Recycled iron and steel scrap is a vital raw material for the production of new steel and cast-iron products. The steel and foundry industries in the United States have been structured to recycle scrap and, as a result, are highly dependent upon scrap. Recycling 1 ton of steel conserves 1.1 tons of iron ore, 0.6 ton of coking coal, and 0.05 ton of limestone. Recycling of scrap also conserves energy because the remelting of scrap requires much less energy than the production of iron or steel products from iron ore.

Overall, the scrap recycling rate in the United States has averaged between 80% and 90% during the past decade, with automobiles making up the primary source of old steel scrap. Recycling of automobiles is nearly 100% each year, with rates fluctuating slightly owing to the rate of new vehicle production and general economic trends. More than 15 million tons per year of steel was recycled from automobiles, the equivalent of approximately 12 million cars, from more than 7,000 vehicle dismantlers and 350 car shredders in North America. The recycling of steel from automobiles is estimated to save the equivalent energy necessary to power 18 million homes every year.

Recycling rates, which fluctuate annually, were estimated to be 98% for structural steel from construction, 88% for appliances, 71% for rebar and reinforcement steel, and 70% for steel packaging in 2024. The recycling rates for appliance, can, and construction steel are expected to increase in the United States and at an even greater rate in emerging industrial countries. Public interest in recycling continues, and recycling is becoming more profitable and convenient as environmental regulations for primary production increase. Also, consumption of iron and steel scrap by remelting reduces the burden on landfill disposal facilities and prevents the accumulation of abandoned steel products in the environment.

Recycled scrap consisted of approximately 58% post-consumer scrap (old, obsolete scrap), 24% new scrap (scrap produced in steel-product manufacturing plants), and 18% home scrap (recirculating scrap from current operations).

Import Sources (2020–23): Canada, 71%; Mexico, 12%; Netherlands, 5%; Sweden, 4%; and other, 8%.

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IRON AND STEEL SCRAP

Tariff: Item	Number	Normal Trade Relations 12–31–24
Ferrous waste and scrap:		
Cast iron	7204.10.0000	Free.
Stainless steel	7204.21.0000	Free.
Other alloy steel	7204.29.0000	Free.
Tinned iron or steel	7204.30.0000	Free.
No. 1 bundles	7204.41.0020	Free.
No. 2 bundles	7204.41.0040	Free.
Borings, shovelings, and turnings	7204.41.0060	Free.
Shavings, chips, and mill waste	7204.41.0080	Free.
No. 1 heavy melting steel	7204.49.0020	Free.
No. 2 heavy melting steel	7204.49.0040	Free.
Cut plate and structural	7204.49.0060	Free.
Shredded steel	7204.49.0070	Free.
Other iron and steel	7204.49.0080	Free.
Remelting ingots	7204.50.0000	Free.
Used rails	7302.10.5040	Free.
Vessels and ships	8908.00.0000	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Events, Trends, and Issues: In the first 8 months of 2024, steel mills maintained normal operating rates of 73% to 78% of production capacity utilization, unchanged from the rates in 2023. Average composite prices published for No. 1 heavy melting steel scrap decreased from the previous high rate of $362.51 per ton in January 2024 to a low of $305.11 per ton in June, July, and August 2024. The annual average price delivered in the first 10 months of 2024 decreased to $327.64 per ton compared with the full-year annual average of $338.63 per ton in 2023. In the first 9 months of 2024, Turkey was the primary destination for exports of ferrous scrap, by tonnage, accounting for 30% of total exports, followed by Mexico, 14%, and Bangladesh, 13%. The value of exported scrap decreased to an estimated $5.0 billion in 2024 from $5.1 billion in 2023. In the first 9 months of 2024, Canada was the leading source of imports of ferrous scrap, by tonnage, accounting for 72% of total imports, followed by Mexico, 21%, and the Netherlands, 3%. The value of imported scrap decreased to an estimated $1.4 billion in 2024 from $1.7 billion in 2023.

The World Steel Association[6] estimated that U.S. production of finished steel products would decrease by 1.5% in 2024 and global finished steel consumption would decrease by 0.9% in 2024. Consumption of finished steel products was expected to decrease owing to issues affecting consumer demand, including geopolitical uncertainties, inflation, and monetary tightening. Effects of economic conditions in major developed nations, with the exception of India, included slowdowns in the automotive, construction, and manufacturing sectors, affecting steel production.

World Production and Reserves: Because scrap is not mined, the concept of reserves does not apply. World production data for scrap were not available. See the Iron and Steel and the Iron Ore chapters.

World Resources: Not applicable. See the Iron Ore chapter.

Substitutes: An estimated 7.5 million tons of direct-reduced iron was consumed in the United States in 2024 as a substitute for iron and steel scrap, compared with 7.0 million tons in 2023.

[e]Estimated. E Net exporter.
[1]See also the Iron and Steel, Iron and Steel Slag, and Iron Ore chapters. A new methodology is being used for reporting consumption, production, and receipts of ferrous scrap. The data are adjusted to reflect an estimation of the U.S. ferrous scrap consumption industry, including specific data for receipts, production, and consumption. An analysis of the previous sampling methodology and reporting showed that the ferrous scrap consumption industry was underreported.
[2]Defined as home scrap + purchased scrap + imports – exports ± adjustments for industry stock changes.
[3]Source: Fastmarkets AMM.
[4]Source: U.S. Department of Labor, Bureau of Labor Statistics, North American Industry Classification System code 331500. See also codes 331100 and 331200 for other steel industry employment data.
[5]Defined as imports – exports ± adjustments for industry stock changes.
[6]Source: World Steel Association, 2024, worldsteel short range outlook October 2024: Brussels, Belgium, World Steel Association press release, October 14, 3 p.

IRON AND STEEL SLAG

(Data in million metric tons unless otherwise specified)

Domestic Production and Use: Iron and steel (ferrous) slags are formed by the combination of slagging agents and impurities during the production of crude (or pig) iron and raw steel. The slags are tapped separately from the metals, then cooled and processed, and are primarily used in the construction industry. Granulated slag is produced at a small number of specially equipped blast furnaces by quenching the molten slag with water to produce sand-sized grains of silicate glass. Pelletized slag, a form of expanded slag, is also produced by quenching blast furnace slag with water; though often used as a lightweight aggregate, it is also used in place of granulated slag when finely ground. Very little is produced in the United States. Ground granulated blast furnace slag (GGBFS) is used as a supplementary cementitious material (SCM) that can partially substitute for clinker in finished cement or for some of the portland cement in concrete. Any other slag produced at blast furnaces is air cooled, including some from blast furnaces equipped with granulators if the slag was not suitable for granulation. Air-cooled blast furnace slag (ACBFS) has for many decades been used in place of natural aggregates in concrete and in smaller specialty markets such as glass and mineral wool insulation. ACBFS also shares end uses with steel furnace slag produced in the basic oxygen furnaces (BOFs) at integrated steel mills and at the electric arc furnaces (EAFs) at steel mills that produce steel mainly from scrap metal. Common end uses for both slag types included asphaltic concrete, fill, and road base. Some iron and steel slags can also be used as a soil conditioner or fertilizer and as filter media in water treatment.

Data were unavailable on actual U.S. ferrous slag production, but slag sales[1] in 2024 were estimated to be 16 million tons valued at about $600 million. Granulated blast furnace slag[2] was less than 3% of the tonnage sold but accounted for about 80% of the total value of slag because of the high value of GGBFS. Steel slag produced from BOFs and EAFs accounted for the remainder of sales. Slag was processed by 25 companies servicing active iron and steel facilities or reprocessing old slag piles at an estimated 120 processing plants (including some iron and steel plants with more than one slag-processing facility) in 33 States, including facilities that import and grind unground slag to sell as GGBFS.

Prices per ton ranged from a few cents for some steel slags at a few locations to about $140 per ton or more for some GGBFS in 2024. Owing to low unit values, most slag types can be shipped only short distances by truck, but rail and waterborne transportation allow for greater travel distances. Because much higher unit values make it economical to ship GGBFS longer distances, much of the GGBFS consumed in the United States is imported.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production (sales)[e, 1]	15	16	16	16	16
Imports for consumption[e, 3]	2.1	2.4	1.7	2.0	1.7
Exports	([4])	([4])	([4])	([4])	([4])
Consumption, apparent[e, 5]	15	16	16	16	16
Price, average unit value, free on board plant, dollars per metric ton[6]	29	28	29	36	38
Employment, number[e]	1,500	1,500	1,500	1,500	1,500
Net import reliance[7] as a percentage of apparent consumption	15	14	11	12	11

Recycling: Following removal of entrained metal, slag can be returned to the blast and steel furnaces as ferrous and flux feed, but data on these returns are incomplete. Entrained metal, particularly in steel slag, is routinely recovered during slag processing for return to the furnaces and is an important revenue source for slag processors; data on metal returns are unavailable.

Import Sources (2020–23): Japan, 52%; China, 23%; Brazil, 11%; Mexico, 5%; and other, 9%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Granulated slag	2618.00.0000	Free.
Slag, dross, scalings, and other waste from manufacture of iron and steel:		
Ferrous scale	2619.00.3000	Free.
Other	2619.00.9000	Free.

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IRON AND STEEL SLAG

Depletion Allowance: Not applicable.

Government Stockpile: None.

Events, Trends, and Issues: In 2024, the supply of domestic GGBFS increased with the startup of a new granulator in the fourth quarter of 2023, bringing the number of domestic granulation operations to four. Construction of another granulator at the same integrated mill was completed and was to be fully operational in 2025. In 2024, permits were obtained to install granulators for both blast furnaces at another integrated steel mill, underscoring the increasing importance of granulated slag for its use as a SCM in blended cements and in concrete. In addition to reducing unit consumption of fuel and limestone in cement plant kilns, which reduces the unit emissions of pollutants such as carbon dioxide, the addition of slag cement in concrete mixtures is advantageous when certain requirements need to be met, such as a lower heat of hydration. Relatively few integrated U.S. steel mills were originally equipped with granulators on their blast furnaces, and for many years as blast furnaces were being shut down, the supply of domestic granulated blast furnace slag decreased; after 2015, there were only two granulators operating. Although the additional granulator capacity coming online will increase the domestic supply, the availability of imported granulated slag will eventually decrease as foreign blast furnaces are shut down in decarbonization efforts and replaced with EAFs and direct-reduced iron facilities such as one being planned for a major integrated mill in Canada. In addition, the domestic supply of fly ash, which is also used as an additive in concrete production similar to GGBFS, was expected to continue to decrease in upcoming years owing to closures of coal-fired powerplants, conversion of powerplants to natural gas, and increasing reliance on renewable energy sources. Granulated slag needs to be ground into a fine powder at grinding plants; a former cement plant was converted to a slag-grinding facility in Indiana, and a new slag cement plant was being built in Texas.

New uses for steel slag were being investigated. In January, the U.S. Department of Transportation offered a grant for research on uses for steel slag in concrete and cement. Typically, ACBFS and GGBFS are used for this purpose, but steel slag is more plentiful. Companies were also working with steel slag in decarbonization efforts such as injecting carbon dioxide into concrete containing steel slag during the curing process.

World Production and Reserves: Because slag is not mined, the concept of reserves does not apply. World production data for slag were not available, but iron slag production from blast furnaces was estimated to be 25% to 30% of crude (pig) iron production, and steel furnace slag production was estimated to be 10% to 15% of raw steel production. In 2024, world iron slag production was estimated to be between 330 million and 390 million tons, and steel slag production was estimated to be between 190 million and 290 million tons.

World Resources: Not applicable.

Substitutes: In the construction sector, ferrous slags compete with natural aggregates (crushed stone and construction sand and gravel) but are far less widely available than the natural materials. As a cementitious additive in blended cements and concrete, GGBFS mainly competes with fly ash, metakaolin, and volcanic ash pozzolans. In this respect, GGBFS reduces the amount of portland cement per ton of concrete, thus allowing more concrete to be made per ton of portland cement. Portland-limestone cement can be used instead of GGBFS for the same purpose. Slags (especially steel slag) can be used as a partial substitute for limestone and some other natural raw materials for clinker (cement) manufacture and compete in this use with fly ash and bottom ash. Some other metallurgical slags, such as copper slag, can compete with ferrous slags in some specialty markets, such as a ferrous feed in clinker manufacture, but the supplies of these metallurgical slags are generally much more restricted than ferrous slags.

[e]Estimated.
[1]Processed slag sold during the year, excluding entrained metal.
[2]Data include sales of domestic and imported granulated blast furnace slag.
[3]U.S. Census Bureau data adjusted by the U.S. Geological Survey to remove nonslag materials (such as cenospheres, fly ash, and silica fume) and slags or other residues of other metallurgical industries (especially copper slag), whose unit values are outside the range expected for granulated slag. In some years, tonnages may be underreported.
[4]Less than 50,000 tons.
[5]Defined as sales – exports.
[6]Average of all types of slag. GGBFS has the highest prices because of its cementitious properties. ACBFS averages a higher price than steel slag, but both are generally lower than prices for aggregates except for some special uses.
[7]Defined as imports – exports.

IRON ORE[1]

(Data in thousand metric tons, usable ore, unless otherwise specified)

Domestic Production and Use: In 2024, eight open pit iron ore mines (each with associated concentration and pelletizing plants) in Michigan, Minnesota, and Utah shipped 98% of domestic usable iron ore products for consumption in the steel industry in the United States. The remaining 2% of domestic iron ore products were consumed in nonsteel end uses. In 2024, the United States produced iron ore with an estimated value of $5.5 billion, a 2% increase from $5.37 billion in 2023. Four iron metallic plants—one direct-reduced iron (DRI) plant in Louisiana and three hot-briquetted iron (HBI) plants in Indiana, Ohio, and Texas—operated during the year to supply steelmaking raw materials with an estimated value of $1.8 billion. The United States was estimated to have produced 1.8% and consumed 1.5% of the world's iron ore output.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Iron ore	37,200	47,900	40,100	44,700	48,000
Iron metallics	3,350	5,010	5,240	5,480	5,300
Shipments	37,400	47,600	40,400	46,400	45,000
Imports for consumption	3,240	3,740	3,040	3,540	2,600
Exports	10,400	14,400	11,400	11,100	10,000
Consumption, Apparent[2]	30,300	37,300	32,000	38,800	37,000
Price, average unit value reported by mines, dollars per metric ton	82.25	141.78	156.42	120.36	115
Stocks, mine, dock, and consuming plant, yearend	3,230	3,510	3,250	1,500	4,000
Employment, mine, concentrating and pelletizing plant, number	4,390	4,980	4,790	4,810	5,000
Net import reliance[3] as a percentage of apparent consumption	E	E	E	E	E

Recycling: None. See the Iron and Steel Scrap chapter.

Import Sources (2020–23): Brazil, 47%; Canada, 30%; Sweden, 13%; Bahrain, 3%; and other, 7%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Iron ores and concentrates:		
Concentrates	2601.11.0030	Free.
Coarse ores	2601.11.0060	Free.
Other ores	2601.11.0090	Free.
Pellets	2601.12.0030	Free.
Briquettes	2601.12.0060	Free.
Sinter	2601.12.0090	Free.
Roasted iron pyrites	2601.20.0000	Free.

Depletion Allowance: 15% (domestic), 14% (foreign).

Government Stockpile: None.

Events, Trends, and Issues: Iron ore production in 2024 was estimated to have increased likely owing to replenishing stocks. Domestic iron ore production was estimated to be 48 million tons in 2024, a 7% increase from 44.7 million tons in 2023. Overall, global prices of iron ore decreased, with an average unit value of $112.06 per ton in the first 9 months of 2024. Pig iron production and raw steel production were estimated to have remained unchanged at 22 million tons and 81 million tons, respectively, in 2024. The World Steel Association[4] estimated global finished steel demand decreased by 0.9% in 2024. Global end-use consumption of steel products was expected to decrease slightly in 2024 owing to global declines or slowdowns in the automotive sector, housing construction, and the manufacturing sector; these decreases were partly offset by investments in climate change mitigation, manufacturing facilities, and public infrastructure.

In February, one company received water permits that would allow for the construction, operation, and closure of a mine permitted for up to 11.5 million tons per year of iron ore mining and processing northeast of Reno, NV. The company also planned to include a colocated merchant pig iron plant at the mine site. In May, one company began production of direct-reduction (DR)-grade iron ore pellets in Hibbing, MN, using an upgrade of the plant's existing production technology that allows for a 4-million-ton-per-year production capacity of DR-grade iron ore pellets with a 67% iron or higher grade that are ideal for consumption in DRI production or in steelmaking furnaces as a higher quality feedstock.

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IRON ORE

Development of one of the world's largest high-grade iron ore deposits, located in Guinea, was expected by yearend 2024 after its ownership was split into a partnership that included the Government of Guinea and multiple international steel companies. Production was expected to start in 2025, and a full production rate of 60 million tons per year was expected by 2028.

The China Iron and Steel Association, an organization that collects data and information on China's steelmaking industry, called for a cut in production in domestic steelmaking, citing rapidly declining prices and the need to balance supply with demand. Following the announcement, China's National Development and Reform Commission cited plans to continue focusing on decarbonization and energy reduction strategies, as well as support for high-quality steelmaking companies and cracking down on illegal or inefficient steelmaking capacity.

In June, Canada's Critical Minerals List was updated to include high-purity iron, citing the necessity of that mineral's role in decarbonization throughout the steel supply chain.

World Mine Production and Reserves: Reserves for Iran, Peru, Russia, South Africa, and the United States were revised based on company and Government reports.

	Mine production				Reserves[5] (million metric tons)	
	Usable ore		Iron content			
	2023	2024[e]	2023	2024[e]	Crude ore	Iron content
United States	44,700	48,000	28,200	30,000	3,600	2,300
Australia	953,000	930,000	589,000	580,000	[6]58,000	[6]27,000
Brazil	445,000	440,000	280,000	280,000	34,000	15,000
Canada	59,400	54,000	35,700	32,000	6,000	2,300
Chile	18,100	18,000	11,400	11,000	NA	NA
China	278,000	270,000	174,000	170,000	20,000	6,900
India	278,000	270,000	172,000	170,000	5,500	3,400
Iran	[e]85,400	90,000	[e]55,900	59,000	3,800	1,500
Kazakhstan	28,900	30,000	8,890	9,200	2,500	900
Mauritania	14,100	15,000	8,790	9,400	NA	NA
Mexico	8,500	8,000	5,350	5,000	NA	NA
Peru	20,900	21,000	14,100	14,000	2,600	1,500
Russia	90,900	91,000	53,300	53,000	35,000	14,000
South Africa	63,200	66,000	40,200	42,000	930	590
Sweden	28,900	28,000	20,400	20,000	1,300	600
Turkey	16,800	18,000	10,100	11,000	150	99
Ukraine	[e]41,700	42,000	[e]26,100	26,000	[7]6,500	[7]2,300
Other countries	52,300	64,000	29,900	37,000	17,000	8,500
World total (rounded)	2,530,000	2,500,000	1,560,000	1,600,000	200,000	88,000

World Resources:[5] U.S. resources are estimated to be 110 billion tons of usable iron ore containing about 27 billion tons of iron. U.S. resources are mainly low-grade taconite-type ores from the Lake Superior district that require beneficiation and agglomeration prior to commercial use. World resources are estimated to be greater than 800 billion tons of iron ore containing more than 230 billion tons of iron.

Substitutes: The only source of primary iron is iron ore, used directly as direct-shipping ore or converted to briquettes, concentrates, DRI, iron nuggets, pellets, or sinter. DRI, iron nuggets, and scrap are extensively used for steelmaking in electric arc furnaces and in iron and steel foundries. Technological advancements have been made that allow hematite to be recovered from tailings basins and pelletized.

[e]Estimated. E Net exporter. NA Not available. — Zero.

[1]Data are for iron ore used as a raw material in steelmaking—excluding iron metallics such as DRI, HBI, and iron nuggets—unless otherwise specified. See also the Iron and Steel and the Iron and Steel Scrap chapters.

[2]Defined as production + imports – exports ± adjustments for industry stock changes.

[3]Defined as imports – exports ± adjustments for industry stock changes.

[4]Source: World Steel Association, 2024, worldsteel short range outlook October 2024: Brussels, Belgium, World Steel Association press release, October 14, 3 p.

[5]See Appendix C for resource and reserve definitions and information concerning data sources.

[6]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 23 billion tons of crude ore and 10 billion tons of iron content.

[7]For Ukraine, reserves consist of the A and B categories of the Soviet reserves classification system.

IRON OXIDE PIGMENTS

(Data in metric tons unless otherwise specified)

Domestic Production and Use: Iron oxide pigments (IOPs) were mined domestically by two companies in Alabama and Georgia. Mine production, which was withheld to avoid disclosing company proprietary data, decreased in 2024 from that in 2023. Five companies with seven processing operations processed and sold about 25,000 tons of finished natural and synthetic IOPs with an estimated value of $51 million. End uses for IOPs include, but are not limited to, concrete and other construction products, paint and coatings, ferrites, plastics, and rubber.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Mine production, crude	W	W	W	W	W
Sold or used, finished natural and synthetic IOPs	18,300	26,900	38,200	25,100	25,000
Imports for consumption	172,000	189,000	225,000	114,000	180,000
Exports, pigment grade	15,700	12,300	13,800	13,100	10,000
Consumption, apparent[1]	174,000	203,000	249,000	126,000	200,000
Price, average unit value, dollars per kilogram[2]	0.72	1.03	1.92	2.03	2.00
Employment, mine and mill, number	47	43	45	44	44
Net import reliance[3] as a percentage of apparent consumption	89	87	85	80	87

Recycling: None.

Import Sources (2020–23): Natural: Cyprus, 55%; France, 19%; Austria, 18%; Belgium, 3%; and other, 5%. Synthetic: China,[4] 43%; Germany, 32%; Brazil, 8%; Canada, 7%; and other, 10%. Total: China,[4] 43%; Germany, 31%; Brazil, 7%; Canada, 7%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Natural:		
Micaceous iron oxides	2530.90.2000	2.9% ad valorem.
Earth colors	2530.90.8015	Free.
Iron oxides and hydroxides containing 70% or more by weight Fe_2O_3:		
Synthetic:		
Black	2821.10.0010	3.7% ad valorem.
Red	2821.10.0020	3.7% ad valorem.
Yellow	2821.10.0030	3.7% ad valorem.
Other	2821.10.0040	3.7% ad valorem.
Earth colors	2821.20.0000	5.5% ad valorem.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

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IRON OXIDE PIGMENTS

Events, Trends, and Issues: In the United States, new privately owned housing starts (not seasonally adjusted), in which IOPs are commonly used to color concrete block and brick, ready-mixed concrete, and roofing tiles, decreased by 4% during the first 8 months of 2024 compared with those in the same period in 2023. IOPs also are used in paints and coatings for the aerospace, automotive, and marine industries. IOPs' characteristics of chemical and thermal stability, color strength, low cost, and weather resistance make IOPs a primary choice for colorant for coatings and construction materials.

Less than 2% of IOP imports were natural pigments, similar to that in all other years in the past decade. Imports of natural and synthetic pigments were estimated to have increased by 58% in 2024 compared with those in 2023, largely owing to increases in synthetic pigment imports. Exports of pigment-grade IOPs were estimated to have decreased by 24% in 2024 compared with those in 2023. Approximately 37% of pigment-grade IOPs exports went to Mexico; the other leading destination countries for exports were China (23%), Belgium (15%), and Chile (6%).

In May 2024, an IOP-producing company based in Singapore closed its plant in Virginia and redistributed production to plants in Georgia and Asia. The plant in Virginia had been in operation for over 100 years.

World Mine Production and Reserves:

	Mine production[e]		Reserves[5]
	2023	2024	
United States	W	W	Moderate
Cyprus	5,000	20,000	Moderate
France	16,000	17,000	NA
Germany[6]	240,000	250,000	Moderate
India (ocher)	3,200,000	3,300,000	37,000,000
Italy	30,000	31,000	NA
Pakistan (ocher)	95,000	100,000	Large
Spain (ocher and red iron oxide)	16,000	17,000	Large
World total (rounded)	[7]NA	[7]NA	Large

World Resources:[5] Domestic and world resources for production of IOPs are adequate. Adequate resources are available worldwide for the manufacture of synthetic IOPs.

Substitutes: Milled IOPs are estimated to be the most commonly used natural minerals for pigments. Because IOPs are color stable, low cost, and nontoxic, they can be economically used for imparting black, brown, red, and yellow coloring in large and relatively low-value applications. Other minerals may be used as colorants, but they generally cannot compete with IOPs because of their higher costs and more limited availability. Synthetic IOPs are widely used as colorants and compete with natural IOPs in many color applications. Organic colorants are used for some colorant applications, but many of the organic compounds fade over time from exposure to sunlight.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Defined as sold or used, finished natural and synthetic iron oxide pigments + imports – exports.
[2]Average unit value for finished iron oxide pigments sold or used by U.S. producers.
[3]Defined as imports – exports.
[4]Includes Hong Kong.
[5]See Appendix C for resource and reserve definitions and information concerning data sources.
[6]Includes natural and synthetic iron oxide pigments.
[7]Several other countries, including Austria, Azerbaijan, Brazil, China, Honduras, Iran, Kazakhstan, Lithuania, Paraguay, Russia, South Africa, Turkey, Ukraine, and the United Kingdom, may have produced iron oxide pigments, but available information was inadequate to make reliable estimates of output.

KYANITE AND RELATED MINERALS

(Data in metric tons unless otherwise specified)

Domestic Production and Use: In Virginia, one firm with integrated mining and processing operations produced an estimated 80,000 tons of kyanite worth $36 million from two hard-rock open pit mines and synthetic mullite by calcining kyanite. Two other companies, one in Alabama and another in Georgia, produced synthetic mullite from materials mined from four sites; each company sourced materials from one site in Alabama and one site in Georgia. Synthetic mullite production data were withheld to avoid disclosing company proprietary data. Commercially produced synthetic mullite is made by sintering or fusing such feedstock materials as kyanite, kaolin, bauxite, or bauxitic kaolin. Natural mullite occurrences typically are rare and not economical to mine.

Of the kyanite-mullite output, 90% was estimated to have been used in refractories and 10% in other uses, including abrasive products, such as motor vehicle brake shoes and pads and grinding and cutting wheels; ceramic products such as electrical insulating porcelains, sanitaryware, and whiteware; foundry products and precision casting molds; and other products. An estimated 60% to 70% of the refractory use was by the iron and steel industries, and the remainder was by industries that manufacture cement, chemicals, glass, nonferrous metals, and other materials.

Andalusite was commercially mined from an andalusite-pyrophyllite-sericite deposit in North Carolina and processed as a blend of primarily andalusite for use by producers of refractories in making firebrick. Another company mined mineral sands in the southeastern United States; product blends that included kyanite and (or) sillimanite were marketed to the abrasive, foundry, and refractory industries.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production:					
Kyanite, mine	[1]67,100	[1]105,000	[1]85,900	[1]82,400	80,000
Synthetic mullite	W	W	W	W	W
Imports for consumption (all kyanite minerals)	714	1,390	7,630	5,020	6,600
Exports (kyanite)	37,400	48,000	51,600	42,800	42,000
Consumption, apparent[2]	30,500	58,400	41,900	44,700	45,000
Price, average unit value of exports (free alongside ship),[3, 4] dollars per metric ton	369	369	382	428	450
Employment, number:[e, 5]					
Kyanite, mine, office, and plant	140	140	140	140	140
Synthetic mullite, office and plant	200	200	200	200	200
Net import reliance[6] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2020–23):[4] South Africa, 40%; Peru, 29%; France, 26%; and United Kingdom, 5%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Andalusite, kyanite, and sillimanite	2508.50.0000	Free.
Mullite	2508.60.0000	Free.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile: None.

Events, Trends, and Issues: Crude steel production in the United States, which ranked fourth in the world, decreased by 1.7% to 53.8 million tons in the first 8 months of 2024 compared with that in the same period in 2023, indicating a similar change in consumption of kyanite-mullite refractories. Global crude steel production decreased by 1.5% to 1,251 million tons during the first 8 months of 2024 compared with that in the same period in 2023. Decreased global crude steel production during the first 8 months of 2024 was partially attributed to decreased demand from end-use sectors. The steel industry continued to be the leading consumer of refractories.

In March 2024, an Austria-based company announced its plan to acquire a United States-based producer of refractory products and associated minerals, pending regulatory approval. A company in South Africa that accounted for nearly one-third of global andalusite output was modernizing its mining and processing facilities.

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KYANITE AND RELATED MINERALS

Andalusite supply remained constrained globally. Over the previous several years, andalusite mines in South Africa were adversely affected by electricity supply disruptions, flooding, and shipping problems; in 2024 mineworkers protested for a wage increase and other demands. In Peru, andalusite production in 2024 was estimated to have been unchanged from that in 2023, but output was not expected to meet demand. Andalusite exports from China were estimated to be less than 9,000 tons, significantly less than those reported from other andalusite-producing countries such as France and Peru. In 2024, a company in France implemented a new water treatment system at its andalusite production facility, which was expected to allow for uninterrupted mining operations. Iran produced andalusite from three andalusite-garnet mines, but information was not available to make a reliable estimate of output.

In India, mining of new groups of minerals, including andalusite, was approved by the Government, but some sillimanite mines had previously been reclassified as beach sand minerals mines and, as a result, those mines were no longer considered sillimanite-producing mines. Beach sand minerals such as garnet, ilmenite, monazite, rutile, sillimanite, and zircon were considered atomic minerals associated with nuclear power generation. Some sillimanite was produced in association with kyanite-producing mines.

If andalusite producers are unable to meet demand, market participants may consider alternatives such as refractory-grade bauxite and mullite. Recycled refractory materials may also be used more often moving forward than they were in 2024.

World Mine Production and Reserves:

	Mine production[e]		Reserves[7]
	2023	2024	
United States (kyanite)	[1]82,400	80,000	Large
China (andalusite, crude ore)	100,000	100,000	5,000,000
France (andalusite)	65,000	60,000	NA
India (kyanite and sillimanite)	3,560	3,600	7,200,000
Peru (andalusite)	40,000	40,000	NA
South Africa (andalusite)	148,000	150,000	NA
World total (rounded)[8, 9]	XX	XX	XX

World Resources:[7] Large resources of kyanite and related minerals are known to exist in the United States. The chief resources are in deposits of micaceous schist and gneiss, mostly in the Appalachian Mountains and in Idaho. Other resources are in aluminous gneiss in southern California. These resources are not economical to mine at present. The characteristics of kyanite resources in the rest of the world are estimated to be similar to those in the United States. Significant resources of andalusite are known to exist in China, France, Peru, and South Africa; kyanite resources have been identified in Brazil, India, and Russia; and sillimanite has been identified in India.

Substitutes: Two types of synthetic mullite (fused and sintered), superduty fire clays, and high-alumina materials are substitutes for kyanite in refractories. Principal raw materials for synthetic mullite are bauxite, kaolin and other clays, and silica sand.

[e]Estimated. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data. XX Not applicable.
[1]Source: Virginia Department of Energy.
[2]Defined as kyanite production + imports of kyanite minerals – exports of kyanite minerals.
[3]Calculated from U.S. Census Bureau export data.
[4]Includes data for the following Harmonized Tariff Schedule of the United States code: 2508.50.0000.
[5]Estimated based on data from the U.S. Department of Labor, Mine Safety and Health Administration.
[6]Defined as imports – exports.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]In addition to the countries and (or) localities listed, Brazil, China, and Iran may have produced kyanite and related materials, but information was not available to make reliable estimates of output.
[9]World totals cannot be calculated because production and reserves are not reported in a consistent manner by all countries.

LEAD

(Data in thousand metric tons, lead content, unless otherwise specified)

Domestic Production and Use: Lead was produced domestically by five lead mines in Missouri plus as a byproduct at two zinc mines in Alaska and two silver mines in Idaho. The value of recoverable lead from ore mined in 2024 was an estimated $670 million compared with $660 million in 2023. Nearly all lead concentrate production has been exported since the last primary lead refinery closed in 2013. The value of the secondary lead produced in 2024 was $2.4 billion, 4% less than that in 2023. The lead-acid battery industry accounted for an estimated 86% of reported U.S. lead consumption during 2024. Lead-acid batteries were primarily used as starting-lighting-ignition (SLI) batteries for automobiles, as industrial-type batteries for standby power for computer and telecommunications networks, and for motive power.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Mine, lead in concentrates	306	294	273	270	300
Mine, recoverable lead	297	286	264	263	290
Primary refinery	—	—	—	—	—
Secondary refinery, old scrap	1,090	1,050	1,010	1,010	1,000
Imports for consumption:					
Lead in concentrates	([1])	1	([1])	([1])	([1])
Refined metal, unwrought	382	614	652	519	420
Exports:					
Lead in concentrates	265	262	255	246	270
Refined metal, unwrought (gross weight)	17	22	26	23	24
Consumption, apparent[2]	1,450	1,640	1,630	1,500	1,400
Price, average, North American, cents per pound[3]	91.3	113.0	116.5	114.1	110
Net import reliance[4] as a percentage of apparent consumption, refined metal	25	36	38	33	28

Recycling: In 2024, an estimated 1 million tons of secondary lead was produced, an amount equivalent to 70% of apparent domestic consumption. Nearly all secondary lead was recovered from old scrap, mostly lead-acid batteries.

Import Sources (2020–23): Refined metal: Canada, 32%; Republic of Korea, 16%; Mexico, 14%; Australia, 11%; and other, 27%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Lead ores and concentrates, lead content	2607.00.0020	1.1¢/kg on lead content.
Refined lead	7801.10.0000	2.5% on the value of the lead content.
Antimonial lead	7801.91.0000	2.5% on the value of the lead content.
Alloys of lead	7801.99.9030	2.5% on the value of the lead content.
Other unwrought lead	7801.99.9050	2.5% on the value of the lead content.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile: None.

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LEAD

Events, Trends, and Issues: During the first 9 months of 2024, the average North American price for lead was 110 cents per pound, 4% less than the annual average price of 114.1 cents per pound in 2023. Global stocks of lead in LME-approved warehouses were 199,000 tons at the end of September, 49% more than those at yearend 2023.

In 2024, domestic mine production of recoverable lead increased by 10% from that in 2023, and production of secondary lead was essentially unchanged from that in 2023. Estimated U.S. apparent consumption of refined lead decreased by 7% from that in 2023, and the net import reliance decreased to 28% from 33%. In the first 9 months of 2024, 20 million spent SLI lead-acid batteries were exported, an 11% increase from 18.5 million batteries exported in the same period in 2023.

According to the International Lead and Zinc Study Group,[5] global refined lead production in 2024 was forecast to increase by 2.4% to 13.5 million tons and refined lead consumption to increase by 0.2% to 13.1 million tons.

World Mine Production and Reserves: Reserves for China and Russia were revised based on Government reports.

	Mine production		Reserves[6]
	2023	2024[e]	
United States	270	300	4,600
Australia	430	430	[7]35,000
Bolivia	60	60	1,600
China	1,960	1,900	22,000
India	226	220	1,900
Iran	[e]60	60	2,000
Mexico	183	180	5,600
Peru	273	270	5,000
Russia	[e]218	220	8,900
Sweden	72	70	1,700
Tajikistan	[e]39	40	NA
Turkey	[e]68	70	1,600
Other countries	511	520	5,900
World total (rounded)	4,370	4,300	96,000

World Resources:[6] Identified world lead resources total more than 2 billion tons. In recent years, significant lead resources have been identified in association with zinc and (or) silver or copper deposits in Australia, China, Ireland, Mexico, Peru, Portugal, Russia, and the United States (Alaska).

Substitutes: Substitution by plastics has reduced the use of lead in cable covering and cans. Tin has replaced lead in solder for potable water systems. The electronics industry has moved toward lead-free solders and flat-panel displays that do not require lead shielding. Steel and zinc are common substitutes for lead in wheel weights.

[e]Estimated. NA Not available. — Zero.
[1]Less than ½ unit.
[2]Defined as primary refined production + secondary refined production from old scrap + refined imports – refined exports.
[3]Source: S&P Global Platts Metals Week.
[4]Defined as refined imports – refined exports.
[5]Source: International Lead and Zinc Study Group, 2024, ILZSG session/forecasts: Lisbon, Portugal, International Lead and Zinc Study Group press release, September 30, [4] p.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 10 million tons.

LIME[1]

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: In 2024, an estimated 16 million tons of quicklime and hydrated lime was produced (excluding independent commercial hydrators[2]), valued at about $3.2 billion. Lime was produced by 26 companies—17 with commercial sales and 9 that produced lime strictly for internal use (for example, sugar companies). These companies had 73 primary lime plants (plants operating quicklime kilns) in 28 States and Puerto Rico. Of the 26 companies, 5 operated only hydrating plants in nine States. In 2024, the five leading U.S. lime companies produced quicklime or hydrated in 22 States and accounted for about 80% of U.S. lime production. Principal producing States were Alabama, Missouri, Ohio, and Texas. Major markets for lime were, in descending order of consumption, steelmaking, chemical and industrial applications (such as the manufacture of fertilizer, glass, paper and pulp, and precipitated calcium carbonate, and in sugar refining), flue gas treatment, construction, water treatment, and nonferrous-metal mining.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production[2, 3]	15,800	16,800	17,000	16,000	16,000
Imports for consumption	308	323	354	343	370
Exports	266	335	304	344	330
Consumption, apparent[4]	15,900	16,800	17,000	16,000	16,000
Price, average value, dollars per metric ton at plant:					
Quicklime	131.4	133.4	151.3	183.1	190
Hydrated	156.0	159.6	183.1	235.0	240
Net import reliance[5] as a percentage of apparent consumption	<1	E	<1	E	<1

Recycling: Large quantities of lime are regenerated by paper mills. Some municipal water-treatment plants regenerate lime from softening sludge. Quicklime is regenerated from waste hydrated lime in the carbide industry. Data for these sources were not included as production to avoid double counting.

Import Sources (2020–23): Canada, 82%; Mexico, 13%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Calcined dolomite	2518.20.0000	3% ad valorem.
Quicklime	2522.10.0000	Free.
Slaked lime	2522.20.0000	Free.
Hydraulic lime	2522.30.0000	Free.

Depletion Allowance: Limestone produced and used for lime production, 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: In 2024, domestic lime production was estimated to be unchanged from that in 2023. However, some of the lime producers have increased product pricing owing to increased costs of production. Several companies were planning to accelerate their decarbonization efforts in the production of lime. In 2024, a total of 73 quicklime plants were in operation along with 10 hydrating plants. Hydrated lime is a dry calcium hydroxide powder made from reacting quicklime with a controlled amount of water in a hydrator. It is used in chemical and industrial, construction, and environmental applications.

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LIME

World Lime Production and Limestone Reserves:

	Production[6]		Reserves[7]
	2023	2024[e]	
United States	16,000	16,000	Adequate for all countries with listed production.
Australia	1,970	2,000	
Belgium[8]	1,040	1,000	
Brazil	8,100	8,100	
Bulgaria	1,310	1,300	
Canada	1,920	1,900	
China	310,000	310,000	
France	3,500	3,500	
Germany	5,700	5,700	
India	17,000	17,000	
Iran	4,000	4,000	
Italy[8]	2,400	2,400	
Japan (quicklime only)	6,010	6,000	
Korea, Republic of	5,100	5,100	
Malaysia	1,500	1,500	
Poland (hydrated and quicklime)	1,280	1,300	
Russia (industrial and construction)	11,400	11,000	
South Africa	1,100	1,100	
Spain	1,700	1,700	
Turkey	4,060	4,100	
Ukraine	1,000	1,000	
United Kingdom	1,400	1,400	
Other countries	17,000	17,000	
World total (rounded)	424,000	420,000	

World Resources:[7] Domestic and world resources of limestone and dolomite suitable for lime manufacture are very large.

Substitutes: Limestone is a substitute for lime in many applications, such as agriculture, fluxing, and sulfur removal. Limestone, which contains less reactive material, is slower to react and may have other disadvantages compared with lime, depending on the application; however, limestone is considerably less expensive than lime. Calcined gypsum is an alternative material in industrial plasters and mortars. Cement, cement kiln dust, fly ash, and lime kiln dust are potential substitutes for some construction uses of lime. Magnesium hydroxide is a substitute for lime in pH control, and magnesium oxide is a substitute for dolomitic lime as a flux in steelmaking.

[e]Estimated. E Net exporter.
[1]Data are for quicklime, hydrated lime, and refractory dead-burned dolomite. Includes Puerto Rico.
[2]To avoid double counting quicklime production, excludes independent commercial hydrators that purchase quicklime for hydration.
[3]Sold or used by producers.
[4]Defined as production + imports – exports. Includes some double counting based on nominal, undifferentiated reporting of company export sales as U.S. production.
[5]Defined as imports – exports.
[6]Only countries that produced 1 million tons or more of lime are listed separately.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]Includes hydraulic lime.

LITHIUM

(Data in metric tons, lithium content, unless otherwise specified)

Domestic Production and Use: Commercial-scale lithium production in the United States was from a continental brine operation in Nevada. Owing to lower lithium prices in 2024, commercial production from the brine-sourced waste tailings of a Utah-based magnesium producer was idled. Two companies produced a wide range of downstream lithium compounds in the United States from domestic or imported lithium carbonate, lithium chloride, and lithium hydroxide. Domestic production data were withheld to avoid disclosing company proprietary data.

Although lithium uses vary by location, global end uses were estimated as follows: batteries, 87%; ceramics and glass, 5%; lubricating greases, 2%; air treatment, 1%; continuous casting mold flux powders, 1%; medical, 1%; and other uses, 3%. Lithium consumption for batteries increased significantly owing to the use of rechargeable lithium batteries in the growing market for electric vehicles (EVs), portable electronic devices, electric tools, and energy grid storage applications. Lithium minerals were used directly as mineral concentrates in ceramics and glass applications.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production	W	W	W	W	W
Imports for consumption	2,460	2,640	3,260	3,390	3,300
Exports	1,200	1,870	2,440	1,960	1,700
Consumption, apparent[1]	W	W	W	W	W
Price, annual average-real, battery-grade lithium carbonate, dollars per metric ton[2]	10,100	14,200	71,100	41,300	14,000
Employment, mine and mill, number	70	70	70	70	70
Net import reliance[3] as a percentage of apparent consumption	>50	>25	>25	>50	>50

Recycling: Construction of lithium battery recycling plants continued throughout 2024. Automobile companies and battery recyclers partnered to supply the automobile industry with a source of battery materials. In October, the U.S. Department of Energy announced $44.8 million in funding from the U.S. Bipartisan Infrastructure Law for eight projects that will help lower EV battery recycling costs, with the long-term goal of lowering vehicle costs.

Import Sources (2020–23): Chile, 50%; Argentina, 47%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Lithium oxide and hydroxide	2825.20.0000	3.7% ad valorem.
Lithium carbonate:		
U.S. pharmaceutical grade	2836.91.0010	3.7% ad valorem.
Other	2836.91.0050	3.7% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile: Not available.

Events, Trends, and Issues: Excluding U.S. production, worldwide lithium production in 2024 increased by 18% to approximately 240,000 tons from 204,000 tons in 2023 in response to strong demand from the lithium-ion battery market, high lithium prices from 2021 to early 2023, and an increase in global lithium production capacity. Global consumption of lithium in 2024 was estimated to be 220,000 tons, a 29% increase from revised consumption of 170,000 tons in 2023. Concern about a short-term lithium oversupply and weaker-than-expected EV sales worldwide during the first half of 2024 caused the price for lithium to decrease considerably throughout the year. Owing in part to incentives and discounts, EV sales in the third quarter of 2024 saw considerable growth in Canada, China, and the United States.

Spot lithium carbonate prices in China [cost, insurance, and freight (c.i.f.)] decreased from approximately $14,500 per ton in January to approximately $9,400 per ton in November. For fixed contracts, the annual average U.S. lithium carbonate price was $14,000 per ton in 2024, a decrease of 66% from that in 2023. Spot lithium hydroxide prices in China [free on board (f.o.b.)] decreased from approximately $17,000 per ton in January to approximately $9,900 per ton in November. Spodumene (6% lithium oxide) prices in Australia (f.o.b.) decreased from approximately $1,250 per ton in January to approximately $730 per ton in November.

Four brine operations in Argentina, nine mineral operations in Australia, one mineral tailings operation in Brazil, two mineral operations in Canada, two brine operations Chile, seven mineral and five brine operations in China, and four mineral operations in Zimbabwe accounted for the majority of world lithium production. Additionally, smaller

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LITHIUM

operations in Australia, Brazil, China, Namibia, Portugal, and the United States also contributed to world lithium production. Despite many lithium projects being postponed or cancelled in 2024 owing to low prices, significant production capacity expansions occurred in Argentina, Chile, China, and Zimbabwe.

In 2024, the U.S. Department of Energy announced $3 billion in funding across 25 projects through the U.S. Bipartisan Infrastructure Law to support new commercial-scale domestic facilities to extract and process lithium and other critical minerals, manufacture key battery components, recycle batteries, support next-generation battery manufacturing, and develop new technologies to increase U.S. lithium reserves.

Lithium supply security has become a priority for technology companies in Asia, Europe, and North America. Strategic alliances and joint ventures among technology companies and exploration companies continued to be established to ensure a reliable, diversified supply of lithium for battery suppliers and vehicle manufacturers. Brine-based lithium sources were in various stages of development or exploration in Argentina, Bolivia, Canada, Chile, China, and the United States; mineral-based lithium sources were in various stages of development or exploration in Australia, Austria, Brazil, Canada, China, Congo (Kinshasa), Czechia, Ethiopia, Finland, France, Germany, Ghana, India, Iran, Kazakhstan, Mali, Namibia, Nigeria, Peru, Portugal, Russia, Rwanda, Serbia, Spain, Thailand, Turkey, the United States, and Zimbabwe; lithium-clay sources were in various stages of development or exploration in Mexico and the United States.

World Mine Production and Reserves: Reserves for Argentina, Australia, Canada, the United States, and Zimbabwe were revised based on company and Government reports.

	Mine production		Reserves[4]
	2023	2024[e]	
United States	W	W	1,800,000
Argentina	8,630	18,000	4,000,000
Australia	91,700	88,000	[5]7,000,000
Brazil	[e]5,260	10,000	390,000
Canada	[e]3,240	4,300	1,200,000
Chile	41,400	49,000	9,300,000
China	[e]35,700	41,000	3,000,000
Namibia	[e]2,700	2,700	14,000
Portugal	[e]380	380	60,000
Zimbabwe	[e]14,900	22,000	480,000
Other countries[6]	—	—	2,800,000
World total (rounded)	[7]204,000	[7]240,000	30,000,000

World Resources:[4] Owing to continuing exploration, measured and indicated lithium resources have increased substantially worldwide and total about 115 million tons. Measured and indicated lithium resources in the United States—from continental brines, claystone, geothermal brines, hectorite, oilfield brines, and pegmatites—are 19 million tons. Measured and indicated lithium resources in other countries have been revised to 96 million tons. Resources are distributed as follows: Argentina, 23 million tons; Bolivia, 23 million tons; Chile, 11 million tons; Australia, 8.9 million tons; China, 6.8 million tons; Canada, 5.7 million tons; Germany, 4 million tons; Congo (Kinshasa), 3 million tons; Mexico, 1.7 million tons; Brazil, 1.3 million tons; Czechia, 1.3 million tons; Mali, 1.2 million tons; Serbia, 1.2 million tons; Peru, 1 million tons; Russia, 1 million tons; Zimbabwe, 860,000 tons; Spain, 320,000 tons; Portugal, 270,000 tons; Namibia, 230,000 tons; Ghana, 200,000 tons; Austria, 60,000 tons; Finland, 55,000 tons; and Kazakhstan, 45,000 tons.

Substitutes: Substitution for lithium compounds is possible in batteries, ceramics, greases, and manufactured glass. Examples are calcium, magnesium, mercury, and zinc as anode material in primary batteries; calcium and aluminum soaps as substitutes for stearates in greases; and sodic and potassic fluxes in ceramics and glass manufacture.

[e]Estimated. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Defined as production + imports – exports ± adjustments for industry stock changes.
[2]Lithium carbonate price assessments for spot and long-term contracts. Source: Benchmark Mineral Intelligence Ltd.
[3]Defined as imports – exports ± adjustments for industry stock changes.
[4]See Appendix C for resource and reserve definitions and information concerning data sources.
[5]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 4.8 million tons.
[6]Other countries with reported reserves include Austria, Congo (Kinshasa), Czechia, Finland, Germany, Ghana, Mali, Mexico, Serbia, and Spain.
[7]Excludes U.S. production.

MAGNESIUM COMPOUNDS[1]

[Data in thousand metric tons, magnesium oxide (MgO) content,[2] unless otherwise specified]

Domestic Production and Use: In 2024, most U.S. magnesium compounds were produced from seawater and natural brines. The value of shipments of all types of magnesium compounds (excluding magnesium chloride) was estimated to be $450 million compared with $449 million (revised) in 2023. Magnesium compounds were recovered from seawater by one company in California and another company in Delaware, from well brines by one company in Michigan, and from lake brines by two companies in Utah. Magnesite was mined by one company in Nevada. One company in Washington sold and processed stockpiled olivine.

In the United States, about 78% of magnesium compounds were consumed in the form of caustic-calcined magnesia, magnesium chloride, magnesium hydroxide, and magnesium sulfates across the following industries and uses, in descending order of quantity, environmental, chemical, agricultural, and deicing. The remaining magnesium compounds were consumed for refractories in the form of dead-burned magnesia, fused magnesia, and olivine.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production	363	432	412	428	430
Shipments (gross weight)	547	634	606	616	620
Imports for consumption	480	655	598	491	520
Exports	66	86	104	89	65
Consumption, apparent[3]	777	1,001	906	830	890
Employment, plant, number[e]	260	270	280	270	270
Net import reliance[4] as a percentage of apparent consumption	53	57	55	48	52

Recycling: Some magnesia-based refractories are recycled as construction aggregate, reused in refractory, and as foundry sand.

Import Sources (2020–23): Caustic-calcined magnesia: China,[5] 73%; Canada, 21%; and other, 6%. Crude magnesite: China,[5] 94%; Japan, 3%; and other, 3%. Dead-burned and fused magnesia: China,[5] 70%; Brazil, 18%; Turkey, 3%; and other, 9%. Magnesium chloride: Israel, 56%; Netherlands, 24%; Austria, 5%; and other, 15%. Magnesium hydroxide: Mexico, 59%; Netherlands, 14%; Israel, 13%; Japan, 5%; and other, 9%. Magnesium sulfates: China,[5] 56%; Germany, 11%; India, 11%; Vietnam, 7%; and other, 15%. Total imports: China,[5] 61%; Israel, 9%; Brazil, 8%; Canada, 8%; and other, 14%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Crude magnesite	2519.10.0000	Free.
Dead-burned and fused magnesia	2519.90.1000	Free.
Caustic-calcined magnesia	2519.90.2000	Free.
Kieserite	2530.20.1000	Free.
Epsom salts	2530.20.2000	Free.
Magnesium hydroxide and peroxide	2816.10.0000	3.1% ad valorem.
Magnesium chloride	2827.31.0000	1.5% ad valorem.
Magnesium sulfate (synthetic)	2833.21.0000	3.7% ad valorem.

Depletion Allowance: Brucite, 10% (domestic and foreign); dolomite, magnesite, and magnesium carbonate, 14% (domestic and foreign); magnesium chloride (from brine wells), 5% (domestic and foreign); and olivine, 22% (domestic) and 14% (foreign).

Government Stockpile: None.

Events, Trends, and Issues: In 2024, China was the leading producer of magnesia and magnesite and remained the principal exporter of magnesia to the United States and much of the world. Based on domestic import data for the year through August, imports from China of caustic-calcined magnesia increased by 90%, and imports of dead burned and fused magnesias from China decreased by 41% compared with those in the same period in 2023. The decrease in dead burned and fused magnesia imports was likely due to the slight decrease in U.S. crude steel production (based on data available through September). Dead burned and fused magnesia were consumed as refractories in steel production. In 2024, estimated domestic apparent consumption of magnesium compounds increased by 7% from that in 2023.

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MAGNESIUM COMPOUNDS

In March, the U.S. Forest Service suspended the use of magnesium chloride-based aerial fire retardants for 2024 after inspections revealed corrosion in airtankers used for distributing the fire retardants. The magnesium chloride-based fire retardant was supplied by the largest domestic producer.

In May, a Finland-based specialty alloy producer acquired the mining rights for magnesite mines in Serbia from a Serbian-based refractory producer. The magnesite was supplied to the company's beneficiation plant in Cacak and sintered in its 100,000-ton-per-year production facility in Kraljevo.

World Magnesite Mine Production and Reserves (gross weight):[6] In addition to magnesite reserves, vast reserves of magnesium exist in well and lake brines and seawater from which magnesium compounds can be recovered. Reserves for China were revised based on Government reports.

	Mine production[e]		Reserves[7]
	2023	2024	
United States	W	W	35,000
Australia	500	490	[8]280,000
Austria	771	760	49,000
Brazil	1,800	1,800	200,000
Canada	150	150	NA
China	13,000	13,000	680,000
Greece	393	390	280,000
India	[9]123	160	66,000
Iran	216	210	10,000
Russia	2,500	2,500	2,300,000
Slovakia	[9]391	380	1,200,000
Spain	680	670	35,000
Turkey	[9]1,330	1,300	110,000
Other countries	373	370	2,500,000
World total (rounded)	[10]22,200	[10]22,000	7,700,000

World Resources:[7] Resources from which magnesium compounds can be recovered range from large to virtually unlimited and are globally widespread. Identified world magnesite and brucite resources total 13 billion tons and several million tons, respectively. Resources of dolomite, forsterite, magnesium-bearing evaporite minerals, and magnesia-bearing brines are estimated to constitute a resource of billions of tons. Magnesium hydroxide can be recovered from seawater. Serpentine could be used as a source of magnesia but global resources, including in tailings of asbestos mines, have not been quantified but are estimated to be very large.

Substitutes: Alumina, chromite, and silica substitute for magnesia in some refractory applications.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]See also the Magnesium Metal chapter.
[2]Reported as magnesium content through Mineral Commodity Summaries 2016. Based on input from consumers, producers, and others involved in the industry, reporting magnesium compound data in terms of magnesium oxide (MgO) content was determined to be more useful than reporting in terms of magnesium content. Calculations were made using MgO contents: magnesite, 47.8%; magnesium chloride, 42.3%; magnesium hydroxide, 69.1%; and magnesium sulfate, 33.5%.
[3]Defined as production + imports – exports.
[4]Defined as imports – exports.
[5]Includes Hong Kong.
[6]Gross weight of magnesite (magnesium carbonate) in thousand tons.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 37 million tons.
[9]Reported.
[10]Excludes U.S. production.

MAGNESIUM METAL[1]

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: One company in Utah had a smelter to recover primary magnesium from brines from the Great Salt Lake in Utah by an electrolytic process but production was estimated to have stopped in 2022. Secondary magnesium was recovered from scrap at smelters that produced magnesium ingot and castings and from aluminum alloy scrap at secondary aluminum smelters. Castings, principally used for the automotive industry, accounted for 65% of reported consumption. Aluminum-base alloys that were used for packaging, transportation, and other applications accounted for 22% of primary magnesium metal consumption; desulfurization of iron and steel, 6%; and all other uses, 7%. About 45% of secondary magnesium was consumed for structural uses, and about 55% was used in aluminum alloys.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Primary	W	W	W	—	—
Secondary (new and old scrap)	95	103	115	108	110
Imports for consumption	65	50	107	88	90
Exports	15	10	9	5	3
Consumption:					
Reported, primary	54	48	50	53	50
Apparent[2]	W	W	W	W	W
Price, annual average:[3]					
U.S. spot Western, dollars per pound	2.48	3.73	7.59	5.00	3.50
European free market, dollars per metric ton	2,149	5,011	5,206	3,240	2,900
Stocks, producer, yearend	W	W	W	W	W
Employment, number[e]	400	400	400	200	200
Net import reliance[4] as a percentage of apparent consumption	>25	>25	>75	>75	>75

Recycling: In 2024, about 27,000 tons of secondary magnesium was recovered from old scrap and 86,000 tons was recovered from new scrap. Aluminum-base alloys accounted for about 50% of the secondary magnesium recovered, and magnesium-based castings, ingot, and other materials accounted for about 50%.

Import Sources (2020–23): Magnesium metal (99.8% purity): Israel, 40%; Turkey, 34%; Russia, 12%; China, 5%; and other, 9%. Magnesium alloys (magnesium content): Czechia, 27%; Taiwan, 16%; Israel, 12%; Republic of Korea, 12%; and other, 33%. Sheet, powder, and other (magnesium content): Austria, 25%; Mexico, 25%; China,[5] 17%; Taiwan, 12%; and other, 21%. Scrap: Canada, 37%; Mexico, 16%; China, 15%; India, 8%; and other, 24%. Combined total (includes magnesium content of alloys, metal, powder, scrap, sheet, and other): Israel, 17%; Canada, 15%; Turkey, 12%; Czechia, 9%; and other, 47%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Unwrought metal	8104.11.0000	8% ad valorem.
Unwrought alloys	8104.19.0000	6.5% ad valorem.
Waste and scrap	8104.20.0000	Free.
Powders and granules	8104.30.0000	4.4% ad valorem.
Wrought metal	8104.90.0000	14.8¢/kg on magnesium content + 3.5% ad valorem.

Depletion Allowance: Dolomite, 14% (domestic and foreign); magnesium chloride (from brine wells), 5% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Production capacity was idle throughout 2024 at the only U.S. primary magnesium smelter. On September 29, 2021, the producer of primary magnesium in Utah declared force majeure on supply contracts, citing equipment failures. Details on the expected restart date were not reported by the company. According to information from the State of Utah, royalty payments for magnesium metal production ceased in 2022. At the end of November 2024, the company laid off 186 employees. The announcement cited discontinuation of lithium carbonate production from its lake brine; many of these employees were likely to have worked on magnesium production prior to the equipment failures in 2021.

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MAGNESIUM METAL

Magnesium prices in the United States generally decreased throughout the year. Import prices in the United States started the year at $3.80 per pound and gradually decreased to $3.25 per pound at the end of November. The price decrease was attributed to decreased demand from aluminum smelters, many of which had significant stocks at the start of the year, as well as secondary aluminum smelters preferring to consume scrap with a high magnesium content. Also, one primary aluminum smelter in Missouri ceased production in January, further decreasing demand for magnesium for aluminum alloys.

Magnesium prices in Europe generally decreased throughout the year. Prices in Europe started the year in a range of $3,050 to $3,200 per ton and gradually decreased to a range of $2,700 to $2,800 per ton at the end of November. The price decrease in Europe was attributed to decreased demand and steady production in China, without major disruption for environmental regulatory enforcement or shortages of coke gas, as was experienced in recent prior years. Coke gas is the energy source used by many magnesium producers in China, the leading supplier of magnesium to consumers in Europe. The 2024 annual average price range for magnesium in Europe was estimated to be 10% less than that in 2023.

In February, the U.S. Department of Defense awarded $28 million in financing through the Defense Production Act Title III program to a company developing a pilot plant in California to produce magnesium metal from sea brine. In April, the company signed an agreement to purchase magnesium chloride from a company that produces salt from seawater. In June, the company announced that it had produced and sold commercial quality magnesium metal from its pilot-plant operations.

World Primary Production and Reserves:

	Smelter production[e]		Smelter capacity[e]
	2023	2024	2024
United States	—	—	[6]64
Brazil	20	20	22
China	[6]805	950	1,800
Iran	5	5	6
Israel	[6]17	20	[6]34
Kazakhstan	22	20	30
Russia	18	15	81
Turkey	13	15	[6]15
Other countries	—	—	52
World total (rounded)	900	1,000	2,100

World Resources:[7] Resources from which magnesium may be recovered range from large to virtually unlimited and are globally widespread. Resources of dolomite, serpentine, and magnesium-bearing evaporite minerals are enormous. Magnesium-bearing brines are estimated to constitute a resource in the billions of tons, and magnesium could be recovered from seawater along world coastlines.

Substitutes: Aluminum and zinc may substitute for magnesium in castings and wrought products. The relatively light weight of magnesium is an advantage over aluminum and zinc in castings and wrought products in most applications; however, its high cost is a disadvantage relative to these substitutes. For iron and steel desulfurization, calcium carbide may be used instead of magnesium. Magnesium is preferred to calcium carbide for desulfurization of iron and steel because calcium carbide produces acetylene in the presence of water.

[e]Estimated. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]See also the Magnesium Compounds chapter.
[2]Defined as primary production + secondary production from old scrap + imports – exports ± adjustments for industry stock changes.
[3]Source: S&P Global Platts Metals Week.
[4]Defined as imports – exports ± adjustments for industry stock changes.
[5]Includes Hong Kong.
[6]Reported.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.

MANGANESE

(Data in thousand metric tons, gross weight, unless otherwise specified)

Domestic Production and Use: Manganese ore containing 20% or more manganese has not been produced domestically since 1970. Manganese ore was consumed mainly by five companies: three companies produced manganese dioxide for pig iron manufacture and two companies produced silicomanganese and ferromanganese. Other companies consumed ore for nonmetallurgical purposes, such as in the production of animal feed, brick colorant, dry cell batteries, and fertilizers.

Salient Statistics—United States:[1]	**2020**	**2021**	**2022**	**2023**	**2024**[e]
Production, mine	—	—	—	—	—
Imports for consumption:					
Manganese ores and concentrates	367	497	566	245	320
Ferromanganese	223	329	330	320	310
Silicomanganese	269	313	420	257	370
Exports:					
Manganese ores and concentrates	1	1	1	2	3
Ferromanganese	5	9	3	2	2
Silicomanganese	2	5	3	4	4
Shipments from Government stockpile:[2]					
Manganese ore	—	2	—	NA	NA
Ferromanganese and manganese metal, electrolytic	54	21	14	NA	NA
Consumption, reported:					
Manganese ore[3]	378	399	357	321	320
Ferromanganese	325	335	339	336	300
Silicomanganese	229	237	234	230	230
Consumption, apparent, manganese content[4]	621	717	804	653	680
Price, average, manganese content, cost, insurance, and freight, China, dollars per metric ton unit[5]	4.58	5.27	5.97	4.80	5.80
Stocks, producer and consumer, yearend:					
Manganese ore[3]	143	220	312	233	230
Ferromanganese	35	40	50	27	30
Silicomanganese	31	34	26	18	20
Net import reliance[6] as a percentage of apparent consumption, manganese content	100	100	100	100	100

Recycling: Manganese was recycled incidentally as a constituent of ferrous and nonferrous scrap; however, scrap recovery specifically for manganese was negligible. Manganese is recovered along with iron from steel slag.

Import Sources (2020–23): Manganese ore: Gabon, 63%; South Africa, 23%; Mexico, 13%; and other, 1%. Ferromanganese: Malaysia, 24%; Australia, 16%; Norway, 15%; South Africa, 14%; and other, 31%. Silicomanganese: Georgia, 26%; South Africa, 25%; Australia, 19%; Malaysia, 9%; and other, 21%. Manganese contained in principal manganese imports:[7] Gabon, 24%; South Africa, 21%; Australia, 10%; Malaysia, 9%; and other, 36%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–24**
Ores and concentrates:		
Containing less than 47% manganese	2602.00.0040	Free.
Containing 47% or more of manganese	2602.00.0060	Free.
Manganese dioxide	2820.10.0000	4.7% ad valorem.
Ferromanganese, containing by weight:		
More than 2% but less than 4% carbon	7202.11.1000	1.4% ad valorem.
More than 4% carbon	7202.11.5000	1.5% ad valorem.
1% or less carbon	7202.19.1000	2.3% ad valorem.
More than 1% but less than 2% carbon	7202.19.5000	1.4% ad valorem.
Ferrosilicon manganese (silicomanganese)	7202.30.0000	3.9% ad valorem.
Metal, unwrought:		
Flake containing at least 99.5% manganese	8111.00.4700	14% ad valorem.
Other	8111.00.4900	14% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

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MANGANESE

Government Stockpile:[8]

Material	FY 2024 Potential acquisitions	FY 2024 Potential disposals	FY 2025 Potential acquisitions	FY 2025 Potential disposals
Manganese ore, metallurgical grade	—	292	—	292
Ferromanganese, high carbon	—	45	—	18
Manganese metal, electrolytic	5	—	5	—

Events, Trends, and Issues: Global production of manganese ore, on a manganese-content basis, increased slightly from that in 2023. Consumption of manganese closely follows the steel industry. The World Steel Association[9] estimated global finished steel consumption would decrease by 0.9% in 2024. An Australia-based company received grants from the U.S. Department of Defense and the U.S. Department of Energy to accelerate development of its manganese mine and battery-grade manganese production facility in Arizona. At least two manganese mining and processing plants in Ukraine have remained idle since November 2023 and another two have resumed minimum production since the second quarter of 2024. A manganese mine in northern Australia suspended its operation owing to a tropical cyclone, which contributed to the increase in manganese ore prices in 2024. In May 2024, the European Union's Critical Raw Materials Act entered into force, which includes high-purity manganese (battery grade) as a strategic raw material and manganese as a critical raw material. Manganese is included in the U.S. list of critical minerals.

World Mine Production (manganese content) and Reserves: Reserves for South Africa were revised based on Government reports.

	Mine production 2023	Mine production 2024[e]	Reserves[10]
United States	—	—	—
Australia	2,860	2,800	[11]500,000
Brazil	[e]580	590	270,000
China	767	770	280,000
Côte d'Ivoire	357	360	NA
Gabon	[e]4,490	4,600	61,000
Ghana	818	820	13,000
India	744	800	34,000
Malaysia	410	410	NA
South Africa	7,300	7,400	560,000
Other countries	1,230	1,300	Small
World total (rounded)	19,600	20,000	1,700,000

World Resources:[10] Land-based manganese resources are large but irregularly distributed; those in the United States are very low grade and have potentially high extraction costs. South Africa accounts for an estimated 70% of the world's manganese resources.

Substitutes: Manganese has no satisfactory substitute in its major applications.

[e]Estimated. NA Not available. — Zero.
[1]Manganese content typically ranges from 35% to 54% for manganese ore and from 74% to 95% for ferromanganese.
[2]Defined as change in total inventory from prior yearend inventory. If negative, increase in inventory. Beginning in 2023, Government stock changes no longer available.
[3]Exclusive of ore consumed directly at iron and steel plants and associated yearend stocks.
[4]Defined for 2020–22 as imports – exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included. Manganese content based on estimates of average content for all significant components—including ferromanganese, manganese dioxide, manganese ore, manganese waste and scrap, silicomanganese, unwrought manganese metal, and wrought manganese metal.
[5]For average metallurgical-grade ore containing 44% manganese. Source: CRU Group.
[6]Defined for 2020–22 as imports – exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.
[7]Includes imports of ferromanganese, manganese dioxide, manganese ore, silicomanganese, and unwrought manganese metal.
[8]See Appendix B for definitions.
[9]Source: World Steel Association, 2024, Short range outlook October 2024: Brussels, Belgium, World Steel Association press release, October 14, 3 p.
[10]See Appendix C for resource and reserve definitions and information concerning data sources.
[11]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 110 million tons.

MERCURY

(Data in metric tons, mercury content, unless otherwise specified)

Domestic Production and Use: Mercury has not been produced as a principal mineral commodity in the United States since 1992. In 2024, mercury was recovered as a byproduct from processing gold-silver ore at several mines in Nevada; however, production data were not reported. Secondary, or recycled, mercury was recovered from batteries, compact and traditional fluorescent lamps, dental amalgam, medical devices, and thermostats, as well as mercury-contaminated soils. The U.S. Environmental Protection Agency (EPA) reported in their 2023 triennial report that domestic production[1] of mercury in 2021 was 103 tons compared with 45 tons produced in 2018 as reported in the EPA's 2020 triennial report. About 182 tons of mercury were stored by manufacturers or producers in 2021 compared with 82 tons of mercury stored in 2018. The reported domestic consumption of mercury and mercury in compounds in products was 13 tons in 2021 compared with 16 tons in 2018. On December 3, 2019, the U.S. Department of Energy (DOE) selected a site near Andrews, TX, to store as much as 6,800 tons of mercury.

The leading domestic end uses of mercury and mercury compounds were relays, sensors, switches, and valves, 65%; dental amalgam, 27%; formulated products (buffers, catalysts, fixatives, and vaccination uses), 7%; and bulbs, lamps, and lighting, 1%. A large quantity of elemental mercury (about 163 tons) is used domestically in manufacturing processes such as catalysts or as a cathode in the chlorine-caustic soda (chloralkali) process. Almost all the mercury is reused in the process. The leading manufacturing processes that use mercury are mercury-cell chloralkali plants. In 2024, only one mercury-cell chloralkali plant operated in the United States.

Until December 31, 2012, domestic- and foreign-sourced mercury was refined and then exported for global use, primarily for small-scale gold mining in many parts of the world. Beginning January 1, 2013, export of elemental mercury from the United States was banned, with some exceptions, under the Mercury Export Ban Act of 2008. Effective January 1, 2020, exports of five mercury compounds were added to that ban.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production[1]	NA	103	NA	NA	NA
Imports for consumption, metal (gross weight)	3	1	2	4	—
Exports, metal (gross weight)	—	—	—	—	—
Consumption, reported	NA	13	NA	NA	NA
Price, average unit value of imports, dollars per kilogram	26	29	33	22	NA
Net import reliance[2] as a percentage of apparent consumption	NA	NA	NA	NA	NA

Recycling: In 2024, eight facilities operated by six companies in the United States accounted for most of the secondary mercury produced and were authorized by the DOE to temporarily store mercury until the DOE's long-term facility opens. Mercury-containing automobile convenience switches, barometers, compact and traditional fluorescent bulbs, computers, dental amalgam, medical devices, and thermostats were collected by smaller companies and shipped to the refining companies for retorting to reclaim the mercury. In addition, many collection companies recovered mercury when retorting was not required. With the rapid replacement of compact and traditional fluorescent lighting by light-emitting-diode (LED) lighting, more mercury was being recycled.

Import Sources (2020–23): Canada, 73%; and China, 27%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Mercury	2805.40.0000	1.7% ad valorem.
Amalgams	2843.90.0000	3.7% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

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MERCURY

Events, Trends, and Issues: Owing to mercury toxicity and concerns for the environment and human health, overall mercury use has declined in the United States and worldwide. According to the United Nations Environment Programme (UNEP) Global Mercury Partnership 2017 report, the top five leading sources of anthropogenic mercury emissions were artisanal and small-scale gold mining (37.7%), stationary combustion of coal (21.3%), nonferrous-metal production (14.7%), cement production (10.5%), and waste from products (6.6%). Mercury is no longer used in most batteries and paints manufactured in the United States. Some button-type batteries, cleansers, fireworks, folk medicines, grandfather clocks, pesticides, and skin-lightening creams and soaps may still contain mercury. Mercury compounds were used as catalysts in the coal-based manufacture of vinyl chloride monomer in China. In some parts of the world, mercury was used in the recovery of gold in artisanal and small-scale mining operations. Conversion to nonmercury technology for chloralkali production and the ultimate closure of the world's mercury-cell chloralkali plants may release a large quantity of mercury to the global market for recycling, sale, or, owing to export bans in Europe and the United States, long-term storage.

Byproduct mercury production is expected to continue from large-scale domestic and foreign gold-silver mining and processing. Domestic mercury consumption will continue to decline owing to increased use of LED lighting and consequent reduced use of conventional fluorescent tubes and compact fluorescent bulbs and continued substitution of non-mercury-containing products in control, dental, and measuring applications.

World Mine Production and Reserves:

	Mine production[e] 2023	Mine production[e] 2024	Reserves[3]
United States	NA	NA	Quantitative estimates of reserves were not available. China, Kyrgyzstan, and Peru have the largest reserves.
China	1,000	1,000	
Kyrgyzstan	6	6	
Morocco	2	2	
Norway	20	20	
Peru (exports)	NA	30	
Tajikistan	100	100	
World total (rounded)[4]	1,130	1,200	

World Resources:[3] China, Kyrgyzstan, Mexico, Peru, Russia, Slovenia, Spain, and Ukraine have most of the world's estimated 600,000 tons of mercury resources. Mexico reclaims mercury from Spanish colonial silver-mining waste. In Spain, once a leading producer of mercury, mining at its centuries-old Almaden Mine stopped in 2003. In the United States, mercury occurrences are in Alaska, Arkansas, California, Nevada, and Texas. The declining consumption of mercury, except for small-scale gold mining, indicates that these resources are sufficient for centuries of use.

Substitutes: Ceramic composites substitute for the dark-gray mercury-containing dental amalgam. "Galinstan," an alloy of gallium, indium, and tin, replaces the mercury used in traditional mercury thermometers, and digital thermometers have replaced traditional thermometers. At chloralkali plants around the world, mercury-cell technology is being replaced by newer diaphragm and membrane-cell technology. LEDs that contain indium substitute for mercury-containing fluorescent lamps. Lithium, nickel-cadmium, and zinc-air batteries replace mercury-zinc batteries in the United States; indium compounds substitute for mercury in alkaline batteries; and organic compounds are being used instead of mercury fungicides in latex paint.

[e]Estimated. NA Not available. — Zero.
[1]Includes byproduct and secondary elemental mercury production and mercury compounds.
[2]Defined as imports – exports.
[3]See Appendix C for resource and reserve definitions and information concerning data sources.
[4]Excludes U.S. production.

MICA (NATURAL)

(Data in metric tons unless otherwise specified)

Domestic Production and Use: Scrap and flake mica production, excluding low-quality sericite, was estimated to be 23,000 tons valued at $3.3 million. Mica was mined in Georgia and North Carolina. Scrap mica was recovered principally from mica and sericite schist and as a byproduct from the production of feldspar and kaolin and the beneficiation of industrial sand. Eight companies produced an estimated 52,000 tons of ground mica valued at about $15 million from domestic and imported scrap and flake mica. Most of the domestic production was processed into small-particle-size mica by either wet or dry grinding. Primary uses were joint compound, oil-well-drilling additives, paint, roofing, and rubber products.

A minor amount of sheet mica has been produced as incidental production from feldspar mining in North Carolina in the past several years. Data on sheet mica production were not available in 2024. The domestic consuming industry was dependent on imports to meet demand for sheet mica. Most sheet mica was fabricated into parts for electrical and electronic equipment.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Scrap and flake:					
Production:[e, 1]					
Sold or used	34,600	40,600	42,000	37,000	23,000
Ground	59,900	66,800	66,300	61,000	52,000
Imports[2]	20,400	24,100	22,600	19,400	20,000
Exports[3]	3,980	4,850	4,450	3,640	4,100
Consumption, apparent[e, 4]	50,000	59,800	60,200	53,000	39,000
Price, average, dollars per metric ton:[e]					
Scrap and flake	120	100	100	100	140
Ground:					
Dry	303	299	300	300	300
Wet	337	336	350	350	310
Net import reliance[5] as a percentage of apparent consumption	31	32	30	30	41
Sheet:					
Sold or used	W	NA	NA	NA	NA
Imports[6]	2,840	3,980	4,300	4,320	4,400
Exports[7]	528	633	804	1,010	800
Consumption, apparent[e, 4]	2,310	3,350	3,490	3,310	3,600
Price, average value, muscovite and phlogopite mica, dollars per kilogram:[e]					
Block	W	W	W	W	W
Splittings	1.57	1.88	1.60	1.80	1.80
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2020–23): Scrap and flake: China, 40%; Canada, 35%; India, 9%; Finland, 5%; and other, 11%. Sheet: China, 79%; Brazil, 6%; India, 4%; and other, 11%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–24**
Split block mica	2525.10.0010	Free.
Mica splittings	2525.10.0020	Free.
Unworked, other	2525.10.0050	Free.
Mica powder	2525.20.0000	Free.
Mica waste	2525.30.0000	Free.
Plates, sheets, and strips of agglomerated or reconstituted mica	6814.10.0000	2.7% ad valorem.
Worked mica and articles of mica, other	6814.90.0000	2.6% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile: None.

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MICA (NATURAL)

Events, Trends, and Issues: Domestic production and consumption of scrap and flake mica was estimated to have decreased significantly in 2024, following the indefinite closure of one facility in South Dakota in late 2023 and storm damage from Hurricane Helene in western North Carolina in October 2024 that caused temporary facility closures in that region. At the beginning of 2024, the number of drill rigs operating in the United States was 622;[8] by the end of October 2024, the number of rigs operating had declined to 585,[8] likely indicating that less mica was consumed in well drilling. Rig counts remained 39% lower than that in the same period in 2019 before the global coronavirus disease 2019 (COVID-19) pandemic in 2020.

Apparent consumption of sheet mica was estimated to have increased by 9% compared with that in 2023, as imports were slightly higher than those in 2023 and exports were lower. Supplies of sheet mica for United States consumption were expected to continue to be from imports, primarily from China and some from Brazil.

World Mine Production and Reserves: World production of sheet mica has remained steady; however, reliable production data for some countries that were estimated to be major contributors to the world total were unavailable. Reserves for the Republic of Korea were revised based on Government reports.

	Scrap and flake			Sheet		
	Mine production[e]		Reserves[9]	Mine production[e]		Reserves[9]
	2023	2024		2023	2024	
United States	37,000	23,000	Large	NA	NA	Very small
Canada	13,000	12,000	Large	NA	NA	NA
China	80,000	80,000	1,100,000	NA	NA	75,000
Finland	[10]49,900	50,000	Large	NA	NA	NA
France	13,000	12,000	Large	NA	NA	NA
India	14,000	13,000	Large	1,000	1,000	110,000
Korea, Republic of	[10]19,900	20,000	12,000,000	—	—	NA
Madagascar	63,000	85,000	Large	—	—	NA
Spain	9,000	9,000	Large	—	—	NA
Turkey	[10]8,720	8,800	620,000	—	—	NA
Other countries	71,000	65,000	Large	200	200	Moderate
World total (rounded)	379,000	380,000	Large	NA	NA	NA

World Resources:[9] Resources of scrap and flake mica are available in clay deposits, granite, pegmatite, and schist, and are considered more than adequate to meet anticipated world demand in the foreseeable future. World resources of sheet mica have not been formally evaluated because of the sporadic occurrence of this material. Large deposits of mica-bearing rock are known to exist in countries such as Brazil, India, and Madagascar. Limited resources of sheet mica are available in the United States. Domestic resources were subeconomic because of the high cost of the hand labor required to mine and process sheet mica from pegmatites.

Substitutes: Some lightweight aggregates, such as diatomite, perlite, and vermiculite, may be substituted for ground mica when used as filler. Ground synthetic fluorophlogopite, a fluorine-rich mica, may replace natural ground mica for uses that require the thermal and electrical properties of mica. Many materials can be substituted for mica in numerous electrical, electronic, and insulation uses. Substitutes include acrylic, cellulose acetate, fiberglass, fishpaper, nylatron, nylon, phenolics, polycarbonate, polyester, polyvinyl chloride, styrene, and vulcanized fiber. Mica paper made from scrap mica can be substituted for sheet mica in electrical and insulation applications.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Excludes low-quality sericite used primarily for brick manufacturing.
[2]Includes data for the following Harmonized Tariff Schedule of the United States codes: 2525.10.0050, <$6.00 per kilogram; 2525.20.0000; and 2525.30.0000.
[3]Includes data for the following Schedule B numbers: 2525.10.0000, <$6.00 per kilogram; 2525.20.0000; and 2525.30.0000.
[4]Defined as sold or used by producing companies + imports – exports.
[5]Defined as imports – exports.
[6]Includes data for the following Harmonized Tariff Schedule of the United States codes: 2525.10.0010; 2525.10.0020; 2525.10.0050, >$6.00 per kilogram; 6814.10.0000; and 6814.90.0000.
[7]Includes data for the following Schedule B numbers: 2525.10.0000, >$6.00 per kilogram; 6814.10.0000; and 6814.90.0000.
[8]Source: Baker Hughes Co., 2024, North America rotary rig count: Baker Hughes Co. (Accessed October 24, 2024, at https://bakerhughesrigcount.gcs-web.com/na-rig-count.)
[9]See Appendix C for resource and reserve definitions and information concerning data sources.
[10]Reported.

MOLYBDENUM

(Data in metric tons, molybdenum content, unless otherwise specified)

Domestic Production and Use: Total estimated U.S. mine production of molybdenum concentrate decreased by 3% to 33,000 tons of molybdenum content in 2024 compared with 34,000 tons in 2023. Molybdenum concentrate production at primary molybdenum mines continued at two operations in Colorado, and molybdenum concentrate production from mines where molybdenum was a byproduct continued at seven operations (four in Arizona and one each in Montana, Nevada, and Utah). Three roasting plants converted molybdenum concentrate to molybdic oxide, from which intermediate products, such as ferromolybdenum, metal powder, and various chemicals, were produced. Molybdenum is a refractory metallic element used principally as an alloying agent in cast iron, steel, and superalloys and is also used in numerous chemical applications, including catalysts, lubricants, and pigments.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, mine	51,100	41,100	34,600	34,000	33,000
Imports for consumption total:					
Ore and concentrates	15,100	15,500	15,700	16,200	16,000
Primary products	9,570	14,700	13,100	13,500	13,000
Exports:					
Ore and concentrates	59,500	55,800	46,200	49,000	45,000
Primary products	3,110	4,150	4,860	4,230	5,500
Consumption:					
Reported[1]	15,800	16,100	15,800	[e]16,000	16,000
Apparent[2]	13,100	11,200	12,300	10,900	12,000
Price, average, dollars per kilogram[3]	19.19	35.62	41.72	54.32	47
Stocks, consumer materials	2,010	2,040	2,040	[e]1,900	1,800
Net import reliance[4] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Molybdenum is recycled as a component of catalysts, ferrous scrap, and superalloy scrap. Ferrous scrap consists of revert, new, and old scrap. Revert scrap refers to remnants manufactured in the steelmaking process. New scrap is generated by steel mill customers and recycled by scrap collectors and processors. Old scrap is largely molybdenum-bearing alloys recycled after serving their useful life. The amount of molybdenum recycled as part of new and old steel and other scrap may be as much as 30% of the apparent supply of molybdenum. There are no processes for the separate recovery and refining of secondary molybdenum from its alloys, but the molybdenum content of the recycled alloys is significant and is reused.

Import Sources (2020–23): Ferromolybdenum: Chile, 77%; Republic of Korea, 19%; United Kingdom, 3%; and other, 1%. Molybdenum ore and concentrates: Peru, 64%; Mexico, 18%; Chile, 12%; Canada, 5%; and other, 1%. Total: Peru, 35%; Chile, 34%; Mexico, 10%; Republic of Korea, 6%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Molybdenum ore and concentrates, roasted	2613.10.0000	12.8¢/kg on molybdenum content + 1.8% ad valorem.
Molybdenum ore and concentrates, other	2613.90.0000	17.8¢/kg on molybdenum content.
Molybdenum chemicals:		
Molybdenum oxides and hydroxides	2825.70.0000	3.2% ad valorem.
Molybdates of ammonium	2841.70.1000	4.3% ad valorem.
Molybdates, all others	2841.70.5000	3.7% ad valorem.
Molybdenum pigments, molybdenum orange	3206.20.0020	3.7% ad valorem.
Ferroalloys, ferromolybdenum	7202.70.0000	4.5% ad valorem.
Molybdenum metals:		
Powders	8102.10.0000	9.1¢/kg on molybdenum content + 1.2% ad valorem.
Unwrought	8102.94.0000	13.9¢/kg on molybdenum content + 1.9% ad valorem.
Wrought bars and rods	8102.95.3000	6.6% ad valorem.
Wrought plates, sheets, strips, and so forth	8102.95.6000	6.6% ad valorem.
Wire	8102.96.0000	4.4% ad valorem.
Waste and scrap	8102.97.0000	Free.
Other	8102.99.0000	3.7% ad valorem.

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MOLYBDENUM

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile: None.

Events, Trends, and Issues: In 2024, the estimated average U.S. molybdic oxide price decreased by 13% compared with that in 2023. Estimated U.S. total imports for consumption of molybdenum decreased slightly compared with those in 2023. Estimated U.S. total exports decreased by 5% compared with those in 2023. Estimated apparent consumption in 2023 increased by 11% compared with that in 2023. In 2024, a Canadian company announced plans to restart its idled Idaho molybdenum mine in the second half of 2027 as well as a progressive rampup to full capacity production at its molybdenum-processing facility in Pennsylvania. Estimated global molybdenum production in 2024 increased by 6% compared with that in 2023. In descending order of production, China, Peru, Chile, the United States, and Mexico provided 90% of total global production. Of the five major producers, only China and the United States produced molybdenum from both primary molybdenum mines and byproduct copper mines; the other countries produced molybdenum as a byproduct from copper mines. Declining ore grades at porphyry copper mines continued to affect molybdenum production. Several large porphyry copper mines are expected to reach end-of-life in the mid-2030s which will further affect future molybdenum supply. Molybdenum was expected to continue to have strong demand in global power generation and infrastructure projects as countries continue to prioritize clean energy to address climate change.

World Mine Production and Reserves: Reserves data for Canada, China, Mongolia, and Peru were revised based on company and Government reports.

	Mine production		Reserves[5]
	2023	2024[e]	(thousand metric tons)
United States	34,000	33,000	3,500
Argentina	—	—	100
Armenia	[e]7,600	8,000	150
Australia	660	1,000	[6]690
Canada	1,150	1,200	64
Chile	44,100	38,000	1,400
China	[e]96,000	110,000	5,900
Iran	[e]2,500	3,000	43
Kazakhstan	3,730	3,900	7
Korea, North	[e]400	700	NA
Korea, Republic of	339	300	8
Mexico	17,500	17,000	130
Mongolia	3,160	3,100	10
Peru	33,500	41,000	1,900
Russia	[e]1,700	1,700	1,100
Uzbekistan	[e]1,700	1,700	21
World total (rounded)	248,000	260,000	15,000

World Resources:[5] Identified resources of molybdenum in the United States are about 5.4 million tons and, in the rest of the world, about 20 million tons. Molybdenum occurs as the principal metal sulfide in large low-grade porphyry molybdenum deposits and as an associated metal sulfide in low-grade porphyry copper deposits. Resources of molybdenum are adequate to supply world needs for the foreseeable future.

Substitutes: There is little substitution for molybdenum in its major application in steels and cast irons. In fact, because of the availability and versatility of molybdenum, industry has sought to develop new materials that benefit from its alloying properties. Potential substitutes include boron, chromium, niobium (columbium), and vanadium in alloy steels; tungsten in tool steels; graphite, tantalum, and tungsten for refractory materials in high-temperature electric furnaces; and cadmium-red, chrome-orange, and organic-orange pigments for molybdenum orange.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Reported consumption of primary products.
[2]Defined as production + imports – exports ± adjustments for all industry stock changes.
[3]U.S. molybdic oxide (MoO_3) price, 57% molybdenum content. Source: Argus Media Group, Argus Non-Ferrous Markets.
[4]Defined as imports – exports ± adjustments for industry stock changes.
[5]See Appendix C for resource and reserve definitions and information concerning data sources.
[6]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 250,000 tons.

NICKEL

(Data in metric tons, nickel content, unless otherwise specified)

Domestic Production and Use: In 2024, the underground Eagle Mine in Michigan produced approximately 8,000 tons of nickel in concentrate, which was exported to smelters in Canada and overseas. Nickel in crystalline sulfate was produced as a byproduct of smelting and refining platinum-group-metal ores mined in Montana. In Missouri, a company produced nickel-copper-cobalt concentrate from historic mine tailings. In the United States, the leading uses for primary nickel were alloys and steels, electroplating, and other uses including catalysts and chemicals. Stainless and alloy steel and nickel-containing alloys typically account for more than 85% of domestic consumption.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Mine	16,700	18,400	17,500	16,400	8,000
Refinery, byproduct	W	W	W	W	W
Secondary	111,000	100,000	[e]97,000	[e]90,000	92,000
Imports:					
Ores and concentrates	95	18	([1])	4	10
Primary	105,000	108,000	127,000	112,000	100,000
Secondary	31,800	34,400	37,300	39,700	40,000
Exports:					
Ores and concentrates	13,400	14,900	15,200	9,100	5,000
Primary	11,300	11,600	11,100	12,200	17,000
Secondary	46,300	29,200	44,400	56,800	48,000
Consumption:					
Reported, primary	96,900	92,100	[e]100,000	[e]110,000	110,000
Reported, secondary, purchased scrap[e]	110,000	100,000	[e]97,000	[e]90,000	92,000
Apparent, primary[2]	94,100	97,500	[e]120,000	[e]100,000	84,000
Apparent, total[3]	205,000	198,000	[e]210,000	[e]190,000	180,000
Price, average annual, London Metal Exchange (LME), cash:					
Dollars per metric ton	13,772	18,476	25,815	21,495	17,000
Dollars per pound	6.25	8.38	11.71	9.75	7.70
Stocks, yearend:					
Consumer	26,900	25,100	23,200	21,600	22,000
LME U.S. warehouses	1,734	1,296	6	1,506	400
Net import reliance[4, 5] as a percentage of total apparent consumption[e]	46	49	55	53	48

Recycling: Most secondary nickel was in the form of nickel content of stainless-steel scrap. Nickel in alloyed form was recovered from the processing of nickel-containing waste. Most recycled nickel was used to produce new alloys and stainless steel. In 2024, nickel recovered from scrap accounted for approximately 54% of apparent consumption.

Import Sources (2020–23): Primary nickel: Canada, 46%; Norway, 11%; Australia, 8%; Brazil, 6%; and other, 29%. Nickel-containing scrap, including nickel content of stainless-steel scrap: Canada, 41%; Mexico, 27%; United Kingdom, 9%; Russia, 4%, and other, 19%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Nickel ores and concentrates, nickel content	2604.00.0040	Free.
Ferronickel	7202.60.0000	Free.
Unwrought nickel, not alloyed	7502.10.0000	Free.
Nickel waste and scrap	7503.00.0000	Free.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile:[6] The U.S. Department of Energy is holding approximately 9,700 tons of radiologically contaminated nickel at Paducah, KY.

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NICKEL

Events, Trends, and Issues: In 2024, the annual average LME nickel cash price was estimated to have decreased by 21% compared with that in 2023. Prices continued their downward trend, having ended 2023 at an average price of $16,400 per metric ton, largely owing to continued surplus of nickel from Indonesia. In early 2024, supply concerns related to nickel asset closures, delays in issuing new nickel mining quotas in Indonesia, social unrest in New Caledonia, and a ban on nickel from Russia increased the LME nickel cash price to about $19,000 per metric ton. However, by June, supply concerns had subsided, and the LME annual average cash price decreased to about $16,000 per metric ton by November.

In May, the U.S. Department of Defense under the Defense Production Act, Title III, awarded a grant of $7 million to a Missouri company to develop a hydrometallurgical demonstration plant to produce cobalt and nickel products. The plant would be capable of extracting the metals from a variety of feedstocks.

Estimated global nickel mine production decreased to an estimated 3.7 million tons in 2024, even though production in Indonesia increased by an estimated 8%. Production in Australia and the Philippines declined by an estimated 26% and 20%, respectively, after multiple companies reduced or halted production owing to unfavorable market conditions related to declining prices and increased production in Indonesia. In New Caledonia, production decreased by an estimated 52% owing to widespread unrest in addition to reduced global nickel prices. In June, a company began commercial production at a new nickel sulfide mine in Kalumbila, Zambia.

World Mine Production and Reserves: Reserves for China and the United States were revised based on company and Government reports.

	Mine production		Reserves[7]
	2023	2024[e]	
United States	16,400	8,000	[8]310,000
Australia	149,000	110,000	[9]24,000,000
Brazil	82,700	77,000	16,000,000
Canada	159,000	190,000	2,200,000
China	[e]117,000	120,000	4,400,000
Indonesia	2,030,000	2,200,000	55,000,000
New Caledonia[10]	231,000	110,000	7,100,000
Philippines	[e]413,000	330,000	4,800,000
Russia	210,000	210,000	8,300,000
Other countries	340,000	300,000	>9,100,000
World total (rounded)	3,750,000	3,700,000	>130,000,000

World Resources:[7] Globally, nickel resources have been estimated to contain more than 350 million tons of nickel, with 54% in laterites and 35% in magmatic sulfide deposits. Hydrothermal systems such as iron-nickel alloy, sedimentary-hosted polymetallic, and volcanogenic massive sulfide deposits, as well as seafloor manganese crusts and nodules contain 10%, and miscellaneous resources such as tailings, 1%.

Substitutes: Low-nickel, duplex, or ultrahigh-chromium stainless steels have been substituted for austenitic grades in construction. Nickel-free specialty steels are sometimes used in place of stainless steel in the power-generating and petrochemical industries. Titanium alloys can substitute for nickel metal or nickel-base alloys in corrosive chemical environments.

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Less than ½ unit.
[2]Defined as primary imports – primary exports ± adjustments for industry stock changes, excluding secondary consumer stocks.
[3]Defined as apparent primary consumption + reported secondary consumption.
[4]Defined as imports – exports ± adjustments for consumer stock changes.
[5]Includes the nickel content of stainless steel and alloy scrap. Excluding scrap, net import reliance would be nearly 100%.
[6]See Appendix B for definitions.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]Includes reserve data for three projects. An additional three domestic projects have defined resources but have not yet defined reserves.
[9]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 8.6 million tons.
[10]Overseas territory of France.

NIOBIUM (COLUMBIUM)

(Data in metric tons, niobium content, unless otherwise specified)

Domestic Production and Use: Significant U.S. niobium mine production has not been reported since 1959. Companies in the United States produced niobium-containing materials from imported niobium concentrates, oxides, and ferroniobium. Niobium was consumed mostly in the form of ferroniobium by the steel industry and as niobium alloys and metal by the aerospace industry. Major end-use distribution of domestic niobium consumption was estimated as follows: steels, about 77%, and superalloys, about 21%. The estimated value of niobium imports was $440 million.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, mine	—	—	—	—	—
Imports for consumption[1]	7,170	8,230	9,110	10,100	8,900
Exports[1]	787	992	668	951	480
Shipments from Government stockpile[2]	−88	−1	—	NA	NA
Consumption:[e]					
Apparent[3]	6,300	7,240	8,440	9,100	8,400
Reported[4]	6,190	6,110	7,230	7,110	6,400
Price, average unit value, ferroniobium, dollars per kilogram[5]	21	21	25	25	26
Net import reliance[3] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Niobium was recycled when niobium-bearing steels and superalloys were recycled; scrap recovery, specifically for niobium content, was negligible. The amount of niobium recycled was not available, but it may have been as much as 20% of apparent consumption.

Import Sources (2020–23): Niobium and tantalum ores and concentrates: Australia, 59%; Congo (Kinshasa), 12%; Mozambique, 6%; United Arab Emirates, 5%; and other, 18%. Niobium oxide: Brazil, 83%; Thailand, 6%; Estonia, 5%; India, 3%; and other, 3%. Ferroniobium and niobium metal: Brazil, 66%; Canada, 29%; Russia, 2%, Germany, 1%, and other, 2%. Total imports: Brazil, 66%; Canada, 27%; and other, 7%. Of U.S. niobium material imports (by niobium content), 71% was ferroniobium, 20% was niobium metal, 8% was niobium oxide, and 1% was niobium ores and concentrates.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Synthetic tantalum-niobium concentrates	2615.90.3000	Free.
Niobium ores and concentrates	2615.90.6030	Free.
Niobium oxide	2825.90.1500	3.7% ad valorem.
Ferroniobium:		
Less than 0.02% phosphorus or sulfur, or less than 0.4% silicon	7202.93.4000	5% ad valorem.
Other	7202.93.8000	5% ad valorem.
Niobium:		
Waste and scrap[6]	8112.92.0700	Free.
Powders and unwrought metal	8112.92.4000	4.9% ad valorem.
Other[6]	8112.99.9100	4% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile:[7]

	FY 2024		FY 2025	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Ferroniobium	136	—	136	—

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NIOBIUM (COLUMBIUM)

Events, Trends, and Issues: In 2024, U.S. niobium apparent consumption (measured in niobium content) was estimated to be 8,400 tons, an 8% decrease from that in 2023. One domestic company developing its project in Nebraska continued to secure financing in 2024. The project, would be the only niobium mine and primary niobium-processing facility in the United States. According to the company, it has secured all necessary construction permits and contracted 75% of its planned ferroniobium production for the first 10 years of operation. According to the results of a 2022 feasibility study, the facility was projected to produce 7,450 tons per year of ferroniobium over a 38-year mine life.

In September, the U.S. Department of Defense awarded $26.4 million to a company with existing tantalum production operations in Boyertown, PA. The award supported establishing high-purity niobium oxide production capabilities. Once operational, the site would be the only high-purity-niobium-processing facility in the United States. High-purity niobium is required for specialty steels and alloys in aerospace applications.

Brazil continued to be the world's leading niobium producer, accounting for approximately 92% of global production, followed by Canada with about 7%. According to international trade statistics under the Harmonized System code 7202.93 (ferroniobium), Brazil's total exports in 2023 were 86,300 tons and were 65,600 tons from January through September 2024. Most of Brazil's exports were sent to China, followed by the Netherlands and the Republic of Korea.

World Mine Production and Reserves:

	Mine production		Reserves[8]
	2023	2024[e]	
United States	—	—	210,000
Brazil	102,000	100,000	16,000,000
Canada	6,700	7,100	1,600,000
Congo (Kinshasa)	740	700	NA
Russia	353	350	NA
Rwanda	210	200	NA
Other countries	121	120	NA
World total (rounded)	110,000	110,000	>17,000,000

World Resources:[8] World resources of niobium are more than adequate to supply projected needs. Most of the world's identified resources of niobium occur as pyrochlore in carbonatite (igneous rocks that contain more than 50%-by-volume carbonate minerals) deposits and are outside the United States.

Substitutes: The following materials can be substituted for niobium, but a performance loss or higher cost may ensue: ceramic matrix composites, molybdenum, tantalum, and tungsten in high-temperature (superalloy) applications; molybdenum, tantalum, and titanium as alloying elements in stainless and high-strength steels; and molybdenum and vanadium as alloying elements in high-strength low-alloy steels.

[e]Estimated. NA Not available. — Zero.

[1]Imports and exports include the estimated niobium content of ferroniobium, niobium and tantalum ores and concentrates, niobium oxide, and niobium powders and unwrought metal. Niobium content was estimated assuming the following: 28% niobium oxide (Nb_2O_5) content in niobium ores and concentrates; 16% Nb_2O_5 content in tantalum ores and concentrates and synthetic concentrates; 100% niobium content in unwrought niobium metal (powders and other); and 65% niobium content in ferroniobium. Nb_2O_5 is 69.904% niobium by weight.

[2]Defined for 2020–22 as change in total inventory from prior yearend inventory. If negative, increase in inventory. Beginning in 2023, Government stock changes no longer included.

[3]Defined for 2020–22 as imports − exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.

[4]Only includes ferroniobium and nickel niobium.

[5]Unit value is weighted average unit value of gross weight of U.S. ferroniobium trade (imports plus exports).

[6]This category includes niobium-containing material and other material.

[7]See Appendix B for definitions.

[8]See Appendix C for resource and reserve definitions and information concerning data sources.

NITROGEN (FIXED)—AMMONIA

(Data in thousand metric tons, nitrogen content, unless otherwise specified)

Domestic Production and Use: Ammonia was produced by 18 companies at 37 plants in 17 States in the United States during 2024; 2 additional plants were idle for the entire year. About 55% of total U.S. ammonia production capacity was in Louisiana, Oklahoma, and Texas because of their large reserves of natural gas, the dominant domestic feedstock for ammonia. In 2024, the U.S. plants actively producing ammonia operated at about 80% of rated capacity. The United States was one of the world's leading producers and consumers of ammonia. Urea, ammonium nitrate, nitric acid, ammonium phosphates, and ammonium sulfate were, in descending order of quantity produced, the major derivatives of ammonia produced in the United States.

Approximately 88% of domestic ammonia production was for fertilizer use, including anhydrous ammonia for direct application, urea, ammonium nitrates, ammonium phosphates, and other nitrogen compounds. Ammonia also was used to produce explosives, plastics, synthetic fibers and resins, and numerous other chemical compounds.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production[1]	14,000	12,700	13,800	13,800	14,000
Imports for consumption	1,990	2,080	1,930	1,720	1,800
Exports	369	231	719	890	880
Consumption, apparent[2]	15,700	14,600	14,800	14,700	15,000
Stocks, producer, yearend	310	270	440	350	440
Price, average, free on board Gulf Coast,[3] dollars per short ton	213	578	1,070	470	440
Employment, plant, number[e]	1,600	1,600	1,600	1,600	1,600
Net import reliance[4] as a percentage of apparent consumption	11	13	7	6	6

Recycling: None.

Import Sources (2020–23): Trinidad and Tobago, 51%; Canada, 47%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Ammonia, anhydrous	2814.10.0000	Free.
Urea	3102.10.0010	Free.
Ammonium sulfate	3102.21.0000	Free.
Ammonium nitrate	3102.30.0000	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Events, Trends, and Issues: The Henry Hub spot natural gas price ranged between $1.25 and $3.25 per million British thermal units for most of the year, with an average of about $2.10 per million British thermal units. Natural gas prices in 2024 were lower than those in 2023—a result of above-average storage levels of natural gas and warmer-than-average winter weather. The Energy Information Administration, U.S. Department of Energy, projected that Henry Hub natural gas spot prices would average around $3.10 per million British thermal units in 2025.

The weekly average Gulf Coast ammonia price was $478 per short ton at the beginning of 2024, decreased to $364 per short ton in late May, and increased to $510 per short ton in late September. The average ammonia price for 2024 was estimated to be $440 per short ton.

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NITROGEN (FIXED)—AMMONIA

Low natural gas prices in the United States have made it economical for companies to upgrade existing ammonia plants and construct new nitrogen facilities. The additional capacity has reduced ammonia imports. Expansion in the U.S. ammonia industry in the next 5 years is expected to increase capacity by about 1.4 million tons per year, which includes decarbonized ammonia projects.

Global ammonia annual capacity is expected to increase by a total of 7% during the next 4 years. Capacity additions were expected in places with low-cost natural gas such as in Asia, Eastern Europe, and North America. As part of the capacity increase, decarbonized ammonia plants have been proposed in several countries but mainly in North America. Consumption of ammonia for fertilizer is expected to increase in Latin America and eastern Asia.

Large corn plantings maintain the continued demand for nitrogen fertilizers in the United States. According to the U.S. Department of Agriculture, U.S. corn growers planted 37.0 million hectares of corn in crop-year 2024 (July 1, 2023, through June 30, 2024), which was 3% less than the area planted in crop-year 2023. Corn acreage in crop-year 2025 is expected to decrease because of anticipated lower returns for corn compared with those of other crops.

World Ammonia Production and Reserves:

	Plant production		Reserves[5]
	2023	2024[e]	
United States	13,800	14,000	Available atmospheric nitrogen and sources of natural gas for production of ammonia were considered adequate for all listed countries.
Algeria	2,000	2,000	
Australia	1,300	1,300	
Canada	3,600	3,600	
China	47,000	47,000	
Egypt	4,500	5,000	
Germany	1,720	1,700	
India	15,300	15,000	
Indonesia	5,800	6,000	
Iran	4,200	4,200	
Malaysia	1,400	1,400	
Netherlands	2,000	2,000	
Nigeria	1,700	1,700	
Oman	2,000	2,000	
Pakistan	3,500	3,500	
Poland	1,560	1,600	
Qatar	3,050	3,100	
Russia	14,000	14,000	
Saudi Arabia	5,400	5,400	
Trinidad and Tobago	3,220	3,200	
Uzbekistan	1,300	1,300	
Vietnam	1,440	1,400	
Other countries	12,300	13,000	
World total (rounded)	152,000	150,000	

World Resources:[5] The availability of nitrogen from the atmosphere for fixed nitrogen production is unlimited. Mineralized occurrences of sodium and potassium nitrates, such as those found in the Atacama Desert of Chile, contribute minimally to the global nitrogen supply.

Substitutes: Nitrogen is an essential plant nutrient that has no substitute. No practical substitutes for nitrogen explosives and blasting agents are known.

[e]Estimated.
[1]Source: The Fertilizer Institute; data adjusted by the U.S. Geological Survey.
[2]Defined as production + imports – exports ± adjustments for industry stock changes.
[3]Source: Green Markets.
[4]Defined as imports – exports ± adjustments for industry stock changes.
[5]See Appendix C for resource and reserve definitions and information concerning data sources.

PEAT

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: The estimated free on board (f.o.b.) mine value of marketable peat sold by producers in the United States was $12 million in 2024. Peat was harvested and processed by 26 companies in 11 States. Three companies were idle in 2024. The top three producing States were Florida, Maine, and Minnesota, which accounted for 52% of the quantity of peat sold. Reed-sedge peat accounted for approximately 87% of the total volume produced, followed by sphagnum moss with an estimated 12%. Domestic peat applications included earthworm culture medium, golf course construction, mixed fertilizers, mushroom culture, nurseries, packing for flowers and plants, seed inoculants, and vegetable cultivation. In the industrial sector, peat was used as an oil absorbent and as an efficient filtration medium for the removal of waterborne contaminants in mine waste streams, municipal storm drainage, and septic systems.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production	354	324	343	[e]310	350
Sales by producers	386	386	497	[e]480	500
Imports for consumption	1,390	1,630	1,440	1,170	1,300
Exports	46	37	43	42	50
Consumption, apparent[1]	1,690	1,970	1,740	[e]1,500	1,600
Price, average unit value, f.o.b. mine, dollars per metric ton	26.07	38.52	26.58	20.00	24
Stocks, producer, yearend	288	235	235	[e]200	220
Employment, mine and plant, number[e]	510	510	510	500	500
Net import reliance[2] as a percentage of apparent consumption	79	84	80	79	78

Recycling: None.

Import Sources (2020–23): Canada, 96%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Peat	2703.00.0000	Free.

Depletion Allowance: 5% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Peat is an important component of plant-growing media, and the demand for peat generally follows that of horticultural applications. Imports in 2024 were estimated to have increased to 1.3 million tons from 1.17 million tons in 2023, and exports were estimated to have increased by 19% to an estimated 50,000 tons from 42,000 tons in 2023. In 2024, peat stocks were estimated to have increased to 220,000 tons from 200,000 tons in 2023. The world's leading peat producers in 2024 were estimated to be, in descending order of production, Finland, Canada, Latvia, Belarus, and Sweden.

Concerns about climate change prompted several countries to plan to decrease or eliminate the use of peat, owing to peatland's ability to act as a carbon sink. Projects in the United States were done in partnership among conservation institutions and local and Federal governments to restore peatlands in Minnesota and North Carolina. In Minnesota, research on how to restore peatlands was done in partnership with a conservation institute, the U.S. Department of Agriculture's Forest Service, the Minnesota Department of Natural Resources, the Minnesota Board of Water and Soil Resources, two local universities, and a local nonprofit organization. In North Carolina, work was done with various Federal and State agencies and institutions to install water management infrastructure, including water control structures, to restore degraded peatlands.

Finland continued to work toward its goal of becoming carbon neutral by 2035. To achieve this, peat production was to be phased out in favor of other forms of noncarbon energy. In the first half of 2024, only 2% of Finland's energy consumption was supplied by peat. Approximately 44% of Finland's energy supply was generated using renewable energy sources, whereas 24% was produced by nuclear energy. Since 2020, new peat harvesting permits were approved for 468 hectares. However, 1,600 hectares of wetlands were established, and 551 hectares of peatland permits were rejected during that same period. The active peat extraction area in Finland was about 19,000 hectares in 2024.

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PEAT

Ireland announced the end of its peat harvesting in 2021, as the country transitioned to alternative fuel sources. However, in October 2024, Ireland's Environmental Protection Agency began investigating outside operators who illegally continued peat extraction in the country. Some of the alleged commercial operations were small-scale peat harvesters, but at least two operations were suspected of being large scale. Ireland's peat briquet production ended in June 2023 when the last factory in Offaly ceased its operation. This plant was originally scheduled to close in 2024, but the quality of the remaining stockpiled peat and the cost of maintaining the facility accelerated its closure. In 2023, the country released a 30-year climate plan that aims to phase out coal and peat-fired electricity generation. Instead, renewable energy sources were expected to generate approximately 80% of Ireland's electricity needs by 2030.

In the United Kingdom throughout 2024, environmental organizations and some politicians called for a shortened timeline for a ban on peat products. A bill was brought forward in Parliament that outlined plans to end the sale of horticultural peat before the end of 2025. The peat-products ban is expected to begin in 2026, with some exemptions delayed until 2030 to prepare for the phaseout. Bagged compost accounted for about half of the extracted peat marketed in the United Kingdom.

World Mine Production and Reserves: Reserves for countries that reported by volume only and had insufficient data for conversion to tonnage were combined and included with "Other countries."

	Mine production		Reserves[3]
	2023	2024[e]	
United States	[e]310	350	150,000
Belarus	[e]2,200	2,200	2,600,000
Canada	3,030	3,000	720,000
Estonia	[e]1,200	1,200	570,000
Finland	[e]3,300	3,300	6,000,000
Germany	1,720	1,700	([4])
Latvia	2,430	2,400	150,000
Lithuania	394	400	210,000
Poland	846	850	([4])
Russia	[e]1,600	1,600	1,000,000
Sweden	1,820	2,000	([4])
Ukraine	440	440	([4])
Other countries[e]	650	600	1,400,000
World total (rounded)	19,900	20,000	13,000,000

World Resources:[3] Peat is a renewable resource, continuing to accumulate on 60% of global peatlands. However, the volume of global peatlands has been decreasing at a rate of 0.05% per year owing to harvesting and land development. Many countries evaluate peat resources based on volume or area because the variations in densities and thickness of peat deposits make it difficult to estimate tonnage. Volume data have been converted using the average bulk density of peat produced in each of those countries. More than 50% of the U.S. peat resources are located in undisturbed areas of Alaska.

Substitutes: Natural organic materials, such as composted yard waste and coir (coconut fiber), compete with peat in horticultural applications. Shredded paper and straw are used to hold moisture for some grass-seeding applications. The superior water-holding capacity and physiochemical properties of peat limit substitution alternatives in most applications.

[e]Estimated.

[1]Defined as production + imports – exports ± adjustments for industry stock changes.

[2]Defined as imports – exports ± adjustments for industry stock changes.

[3]See Appendix C for resource and reserve definitions and information concerning data sources.

[4]Included with "Other countries."

PERLITE

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: In 2024, the quantity of domestic processed crude perlite sold and used was estimated to be 440,000 tons with a value of $33 million. Crude ore production was from nine mines operated by six companies in six Western States. New Mexico continued to be the leading producing State. Domestic apparent consumption of crude perlite was estimated to be 590,000 tons. Processed crude perlite was expanded at 53 plants in 29 States. The applications for expanded perlite were building construction products, 47%; horticultural aggregate, 16%; filter aids, 14%; and other, 23%. Other applications included fillers, which had been a leading end use in prior years but is withheld to avoid disclosing company proprietary data, as well as specialty insulation and miscellaneous uses.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Mine production, crude ore	853	879	672	654	690
Sold or used, processed crude perlite[1]	501	491	442	410	440
Imports for consumption[2]	160	170	240	140	180
Exports[2]	25	27	22	18	27
Consumption, apparent[3]	640	630	660	530	590
Price, average value, free on board mine, dollars per metric ton	61	64	69	74	75
Employment, mine and mill, number	140	150	150	150	150
Net import reliance[4] as a percentage of apparent consumption	21	23	33	23	26

Recycling: Not available.

Import Sources (2020–23): Greece, 93%; China, 4%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Vermiculite, perlite, and chlorites, unexpanded	2530.10.0000	Free.

Depletion Allowance: 10% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Perlite is a siliceous volcanic glass that expands up to 20 times its original volume when rapidly heated. Construction applications for expanded perlite are numerous because it is fire resistant, an excellent insulator, and lightweight. In horticultural uses, expanded perlite is used to provide moisture retention and aeration without compaction when added to soil. Horticultural perlite is useful to both commercial growers and hobby gardeners. Owing primarily to cost, some commercial greenhouse growers in the United States have recently switched to a wood fiber material instead of perlite. Perlite, however, remained a preferred soil amendment for segments of greenhouse growers because it does not degrade or compact over lengthy growing times and is inert. Perlite has replaced vermiculite in some horticulture products owing to difficulties in acquiring vermiculite due to low production and prior transportation issues. Cosmetics, environmental remediation, and personal care products have become increasing markets for perlite.

In April 2024, a leading global producer of industrial minerals headquartered in France entered into negotiations with a Pittsburgh, PA, based global company to acquire its European diatomite and perlite business. The acquisition, which consists of three mining and industrial assets in France and Italy, is expected to be completed by the end of 2024.

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PERLITE

The amount of processed perlite sold or used from U.S. mines increased in 2024 compared with the amount in 2023. Imports also increased from those in 2023, and apparent consumption increased to about 590,000 tons. Constructed-related uses have consistently been the leading use of perlite. The value of total construction put in place in the United States increased by about 8% during the first 8 months of 2024 compared with that in the same period in 2023. However, the increase of value was affected by increases in the price of construction materials. During the first 9 months of 2024, housing starts in the United States decreased by about 3% compared to those in the same period in 2023.

The world's leading perlite producers in 2024 were, in descending order of quantity, China, 35%; Turkey, 28%; Greece, 20%; and the United States, 10%. Although China was the leading producer, most of its perlite production was estimated to be consumed internally. Greece and Turkey remained the world's leading exporters of perlite.

World Mine Production and Reserves:

	Production[e]		Reserves[5]
	2023	**2024**	
United States[1]	[6,7]410	[6]440	50,000
Argentina	32	30	NA
Armenia	29	30	NA
China	1,500	1,500	32,000
Georgia	38	40	NA
Greece	840	850	180,000
Hungary[8]	77	80	NA
Mexico[8]	29	30	NA
New Zealand	18	20	NA
Philippines	[7]18	20	NA
Slovakia	39	40	30,000
South Africa	11	10	NA
Turkey[8]	[7]1,170	1,200	NA
Other countries	19	20	NA
World total (rounded)	4,230	4,300	NA

World Resources:[5] Perlite occurrences in Arizona, California, Idaho, Nevada, New Mexico, and Oregon may contain large resources. Significant deposits have been reported in China, Greece, Turkey, and a few other countries. Available information was insufficient to make reliable estimates of resources in many perlite-producing countries.

Substitutes: In construction applications, diatomite, expanded clay and shale, pumice, and slag can be substituted for perlite. For horticultural uses, coco coir, pumice, vermiculite, and wood pulp are alternative soil additives and are sometimes used in conjunction with perlite.

[e]Estimated. NA Not available.
[1]Beginning in 2023, production data were rounded to two significant digits to avoid disclosing proprietary information.
[2]Exports and imports were estimated by the U.S. Geological Survey from U.S. Census Bureau combined data for vermiculite, perlite, and chlorites, unexpanded. Data are rounded to two significant digits.
[3]Defined as processed crude perlite sold and used + imports – exports. Data are rounded to two significant digits.
[4]Defined as imports − exports.
[5]See Appendix C for resource and reserve definitions and information concerning data sources.
[6]Processed ore sold and used by producers.
[7]Reported.
[8]Crude ore.

PHOSPHATE ROCK

(Data in thousand metric tons, marketable phosphate rock, unless otherwise specified)

Domestic Production and Use: In 2024, phosphate rock ore was mined by five companies at 10 mines in four States and processed into an estimated 20 million tons of marketable product, valued at $2 billion, free on board (f.o.b.) mine. Phosphate rock was produced in Florida, Idaho, North Carolina, and Utah. Marketable product refers to beneficiated phosphate rock with phosphorus pentoxide (P_2O_5) content suitable for phosphoric acid or elemental phosphorus production. More than 95% of the phosphate rock mined in the United States was used to manufacture wet-process phosphoric acid and superphosphoric acid, which were used as intermediate feedstocks in the manufacture of granular and liquid ammonium phosphate fertilizers and animal feed supplements. About 25% of the wet-process phosphoric acid produced was exported in the form of upgraded granular diammonium phosphate (DAP), monoammonium phosphate (MAP) fertilizer, merchant-grade phosphoric acid, and other phosphate fertilizer products. The balance of the phosphate rock mined was for the manufacture of elemental phosphorus, which was used to produce phosphorus compounds for industrial applications, primarily glyphosate herbicide.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production, marketable	23,500	21,600	[e]19,800	[e]19,600	20,000
Sold or used by producers	22,600	21,900	[e]19,800	[e]20,000	19,000
Imports for consumption	2,520	2,460	2,500	2,590	3,500
Consumption, apparent[1]	25,100	24,400	[e]22,300	[e]22,600	23,000
Price, average value, f.o.b. mine,[2] dollars per metric ton	76	83	[e]99	[e]101	100
Stocks, producer, yearend	11,000	10,700	[e]10,600	[e]9,550	10,000
Employment, mine and beneficiation plant, number[e]	1,800	2,000	1,900	1,900	1,900
Net import reliance[3] as a percentage of apparent consumption	6	11	12	16	13

Recycling: None.

Import Sources (2020–23): Peru, 98%; and Morocco, 2%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Natural calcium phosphates:		
Unground	2510.10.0000	Free.
Ground	2510.20.0000	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: U.S. production and consumption of phosphate in 2024 were estimated to have increased slightly from those in 2023. Imports were estimated to have increased by 35% to 3.5 million tons in 2024.

Storm damage from Hurricane Helene and Hurricane Milton caused flooding at phosphate plants and mines in central Florida in September and October 2024. Several facilities were closed for as much as 2 weeks, and fertilizer production and shipments were halted during that period.

Global production of phosphate rock was estimated to be slightly higher than that in 2023, with China, Morocco, the United States, and Russia, in descending order of production, remaining the leading producers. World consumption of P_2O_5 contained in fertilizers was estimated to have been 47.5 million tons in 2024 compared with 45.8 million tons in 2023. World consumption of P_2O_5 in fertilizers was projected to increase to 51.8 million tons by 2028. The leading regions for growth were expected to be Asia and South America.

The two new mines and associated purified phosphoric acid plants were under development in Quebec, Canada. One company planned to focus exclusively on the manufacturing of lithium-iron-phosphate (LFP) battery cathode active material (CAM) and will have its own facility to produce iron phosphate CAM. The other company planned to produce high-purity phosphoric acid for both LFP CAM and established food and industrial applications. In 2024, more than 90% of all LFP batteries were manufactured in China.

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PHOSPHATE ROCK

Global phosphate production capacity, in terms of P_2O_5 content, was projected to increase to 70.6 million tons by 2028 compared with 65.0 million tons in 2024. Capacity expansions to phosphate rock production that were expected to be completed by 2027 were ongoing in Brazil, Kazakhstan, Mexico, Morocco, and Russia. Significant new mining projects that were planned to be completed after 2027 were under development in Canada, Congo (Brazzaville), Guinea-Bissau, and Senegal.

World Mine Production and Reserves: Reserves for China and Saudi Arabia were revised based on company and Government reports.

	Mine production[e]		Reserves[4]
	2023	2024	
United States	19,600	20,000	1,000,000
Algeria	2,000	2,000	2,200,000
Australia	2,500	2,500	[5]1,100,000
Brazil	5,280	5,300	1,600,000
China[6]	105,000	110,000	3,700,000
Egypt	5,000	5,000	2,800,000
Finland	906	900	1,000,000
India	1,800	1,600	31,000
Israel	2,310	2,300	60,000
Jordan	11,500	12,000	1,000,000
Kazakhstan	1,500	1,700	260,000
Mexico	439	360	30,000
Morocco	33,000	30,000	50,000,000
Peru	4,700	5,000	210,000
Russia	13,000	14,000	2,400,000
Saudi Arabia	9,900	9,500	1,000,000
Senegal	2,400	2,500	50,000
South Africa	1,720	2,200	1,500,000
Syria	800	2,000	250,000
Togo	1,610	1,500	30,000
Tunisia	3,600	3,300	2,500,000
Turkey	960	800	71,000
Uzbekistan	800	900	100,000
Vietnam	2,500	2,600	30,000
Other countries	730	770	800,000
World total (rounded)	233,000	240,000	74,000,000

World Resources:[4] Some world reserves were reported only in terms of ore tonnage and grade. Phosphate rock resources occur principally as sedimentary marine phosphorites. The largest sedimentary deposits are found in northern Africa, the Middle East, China, and the United States. Significant igneous occurrences are found in Brazil, Canada, Finland, Russia, and South Africa. Large phosphate resources have been identified on the continental shelves and on seamounts in the Atlantic Ocean and the Pacific Ocean. World resources of phosphate rock are more than 300 billion tons. There are no imminent shortages of phosphate rock.

Substitutes: There are no substitutes for phosphorus in agriculture.

[e]Estimated.

[1]Defined as phosphate rock sold or used by producers + imports. U.S. producers stopped exporting phosphate rock in 2003.

[2]Marketable phosphate rock, weighted value, all grades.

[3]Defined as imports ± adjustments for industry stock changes.

[4]See Appendix C for resource and reserve definitions and information concerning data sources.

[5]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 120 million tons.

[6]Production data for large mines only, as reported by the National Bureau of Statistics of China.

PLATINUM-GROUP METALS

(Palladium, platinum, iridium, osmium, rhodium, and ruthenium)
[Data in kilograms, platinum-group-metal (PGM) content, unless otherwise specified]

Domestic Production and Use: One company in Montana mined and processed PGMs with an estimated value of about $310 million in 2024, a decrease of 42% compared with $541 million in 2023. Small quantities of PGMs also were recovered as byproducts of copper-nickel mining in Michigan; however, this material was sold to foreign companies for refining. The leading domestic use for PGMs was in catalytic converters to decrease harmful emissions from automobiles. PGMs are also used in catalysts for bulk-chemical production and petroleum refining; dental and medical devices; electronic applications, such as in computer hard disks, hybridized integrated circuits, and multilayer ceramic capacitors; glass manufacturing; investment; jewelry; and laboratory equipment.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Mine production:[1]					
Palladium	14,600	13,700	10,100	10,300	8,000
Platinum	4,200	4,020	3,000	3,040	2,000
Imports for consumption:[2]					
Palladium	76,400	72,600	65,200	66,900	69,000
Platinum	64,900	67,900	64,200	66,800	72,000
PGM waste and scrap	185,000	160,000	41,500	32,000	36,000
Iridium	1,620	2,310	1,610	2,040	1,400
Osmium	1	1	1	—	1
Rhodium	20,700	16,500	13,200	12,100	15,000
Ruthenium	13,900	18,000	13,300	10,800	10,000
Exports:[3]					
Palladium	48,600	43,900	42,200	33,600	39,000
Platinum	28,900	29,400	23,100	11,300	12,000
PGM waste and scrap	33,200	37,800	35,200	13,900	13,000
Rhodium	1,480	1,350	717	453	1,000
Other PGMs	1,440	2,180	1,010	845	2,000
Consumption, apparent:[4,5]					
Palladium	82,300	81,400	74,100	88,600	83,000
Platinum	47,300	51,100	52,900	67,000	71,000
Price, dollars per troy ounce:[6]					
Palladium	2,205.27	2,419.18	2,133.81	1,351.66	980
Platinum	886.02	1,094.31	966.54	973.00	950
Iridium	1,633.51	5,158.40	4,581.93	4,672.78	4,800
Rhodium	11,205.06	20,254.10	15,585.00	6,660.58	4,600
Ruthenium	271.83	576.12	577.02	466.49	440
Employment, mine, number	1,480	1,600	1,560	1,450	900
Net import reliance[5, 7] as a percentage of apparent consumption:					
Palladium	34	35	31	38	36
Platinum	76	75	78	83	85

Recycling: About 120,000 kilograms of palladium and platinum were recovered globally from new and old scrap in 2024, including about 45,000 kilograms of palladium and 8,500 kilograms of platinum recovered from automobile catalytic converters in the United States.

Import Sources (2020–23): Palladium: Russia, 32%; South Africa, 32%; Belgium, 8%, Italy, 8%; and other, 20%. Platinum: South Africa, 45%; Belgium, 12%; Germany, 10%; Italy, 9%; and other, 24%.

Tariff: All unwrought and semimanufactured forms of PGMs are imported duty free. See footnote 2 for specific Harmonized Tariff Schedule of the United States codes.

Depletion Allowance: 22% (domestic), 14% (foreign).

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PLATINUM-GROUP METALS

Government Stockpile:[8]

Material	FY 2024 Potential acquisitions	FY 2024 Potential disposals	FY 2025 Potential acquisitions	FY 2025 Potential disposals
Iridium	—	15	—	15
Platinum	—	261	—	261

Events, Trends, and Issues: Production at a domestic mine continued, but the company placed one of its operations on care-and-maintenance status and reduced the number of its employees owing to the high cost of operations and decreases in PGM prices. Production of PGMs in South Africa, the world's leading producer of PGM-containing mined material, decreased compared with that in 2023 owing to declining prices, higher costs associated with deep-level mining, labor disputes, and ongoing disruptions to the supply of electricity. Production in Russia, the world's leading producer of mined palladium, decreased owing to disruptions from natural disasters, lower metal grades and ore recovery, ongoing issues related to the Russia-Ukraine conflict, and planned outages at a major metallurgical plant.

The estimated annual average price for iridium in 2024 increased by 3% compared with the average price in 2023 whereas the estimated annual average prices for rhodium decreased by 31% for rhodium, by 27% for palladium, by 6% for ruthenium, and slightly for platinum compared with annual average prices in 2023. Price decreases were attributed to decreased demand, investor uncertainty, and oversupply.

World Mine Production and Reserves: Reserves for Russia were revised based on a Government report.

	Mine production				PGM reserves[9]
	Palladium		Platinum		
	2023	2024[e]	2023	2024[e]	
United States	10,300	8,000	3,040	2,000	820,000
Canada	16,100	15,000	5,170	5,200	310,000
Russia[e]	87,000	75,000	21,000	18,000	[10]16,000,000
South Africa	74,900	72,000	125,000	120,000	63,000,000
Zimbabwe	15,900	15,000	19,200	19,000	1,200,000
Other countries	4,200	4,200	5,710	4,600	NA
World total (rounded)	208,000	190,000	179,000	170,000	>81,000,000

World Resources:[9] World resources of PGMs are estimated to total more than 100 million kilograms. The largest resources and reserves are in the Bushveld Complex in South Africa.

Substitutes: Palladium has been used as a substitute for platinum in most gasoline-engine catalytic converters because of the historically lower price for palladium relative to that of platinum. About 25% of palladium can routinely be substituted for platinum in diesel catalytic converters; the proportion can be as much as 50% in some applications. For some industrial end uses, one PGM can substitute for another, but with losses in efficiency.

[e]Estimated. NA Not available. — Zero.
[1]Estimated from published sources.
[2]Includes data for the following Harmonized Tariff Schedule of the United States codes: 7110.11.0010, 7110.11.0020, 7110.11.0050, 7110.19.0000, 7110.21.0000, 7110.29.0000, 7110.31.0000, 7110.39.0000, 7110.41.0010, 7110.41.0020, 7110.41.0030, 7110.49.0010, and 7118.90.0020; 7112.92.0000 (2020–21); and 7112.92.0100 (2022–24).
[3]Includes data for the following Schedule B numbers: 7110.11.0000, 7110.19.0000, 7110.21.0000, 7110.29.0000, 7110.31.0000, 7110.39.0000, 7110.41.0000, and 7110.49.0000; 7112.92.0000 (2020–21); and 7112.92.0100 (2022–24).
[4]Defined as primary production + secondary production + imports – exports.
[5]Excludes imports and (or) exports of waste and scrap.
[6]Engelhard unfabricated metal average annual prices. Source: S&P Global Platts Metals Week.
[7]Defined as imports – exports.
[8]See Appendix B for definitions.
[9]See Appendix C for resource and reserve definitions and information concerning data sources.
[10]Reserves for Russia are based on the Russian Classification system A+B+C1+C2, where C2 are deposits that are being developed or prepared for development.

POTASH

[Data in thousand metric tons, potassium oxide (K_2O) equivalent, unless otherwise specified]

Domestic Production and Use: In 2024, the estimated sales value of marketable potash, free on board (f.o.b.) mine, was $530 million, which was 6% higher than that in 2023. The majority of U.S. production was from southeastern New Mexico, where two companies operated two underground mines and one deep-well solution mine. Sylvinite and langbeinite ores in New Mexico were beneficiated by flotation, dissolution-recrystallization, heavy-media separation, solar evaporation, and (or) combinations of these processes. In Utah, two companies operated three facilities. One company extracted underground sylvinite ore by deep-well solution mining. Solar evaporation crystallized the sylvinite ore from the brine solution, and a flotation process separated the muriate of potash (MOP) from byproduct sodium chloride. The firm also processed subsurface brines by solar evaporation and flotation to produce MOP at its other facility. Another company processed brine from the Great Salt Lake by solar evaporation to produce potassium sulfate or sulfate of potash (SOP) and other byproducts.

Potash denotes a variety of mined and manufactured salts that contain the element potassium in water-soluble form. In agriculture, the term potash refers to potassic fertilizers, which are potassium chloride (KCl), SOP, and potassium magnesium sulfate (SOPM) or langbeinite. MOP is an agriculturally acceptable mix of KCl (95% pure or greater) and sodium chloride for fertilizer use. The fertilizer industry used about 85% of U.S. potash sales, and the remainder was used for chemical and industrial applications. About 70% of the potash produced was SOPM and SOP, which are required to fertilize certain chloride-sensitive crops. The remainder of production was MOP and was used for agricultural and chemical applications.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, marketable[1]	460	480	430	390	420
Sales by producers, marketable[1]	500	490	400	400	440
Imports for consumption	5,370	6,480	4,940	5,680	6,100
Exports	147	112	267	165	100
Consumption, apparent[1, 2]	5,700	6,900	5,100	5,900	6,400
Price, average, f.o.b. mine, dollars per metric ton of K_2O equivalent:					
All products[3]	850	1,120	1,790	1,250	1,220
MOP	450	650	980	620	630
Employment, mine and mill, number[e]	900	900	900	900	900
Net import reliance[4] as a percentage of apparent consumption	92	93	92	93	93

Recycling: None.

Import Sources (2020–23): Canada, 79%; Russia, 11%; Belarus, 4%; Israel, 3%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Potassium nitrate	2834.21.0000	Free.
Potassium chloride	3104.20.0000	Free.
Potassium chloride, less than or equal to 62% K_2O	3104.20.0010	Free.
Potassium chloride, greater than 62% K_2O	3104.20.0050	Free.
Potassium sulfate	3104.30.0000	Free.
Potassic fertilizers, other	3104.90.0100	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic consumption, production, and sales of potash all were estimated to have increased in 2024. Good weather during the planting seasons and steady potash prices for farmers contributed to the increase in consumption. World potash consumption was estimated to have been 38.8 million tons in 2024, an increase from 37.5 million tons in 2023. World consumption was projected to increase to 40.9 million tons in 2025. Asia and South America were the regions with the highest growth in consumption.

World potash production was estimated to have increased in 2024, with Belarus and Canada having the largest increases in production from that in 2023. Canada was the leading exporter of potash in the world in 2024, as it increased sales to meet growth in world consumption. Belarus production almost returned to levels prior to 2022, when the European Union and the United States placed sanctions on the State-run Belarusian potash-exporting company.

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POTASH

Exports from Belarus, however, where still much lower than those prior to 2022, when Lithuania terminated the contract that allowed Belarus to export potash from the port of Klaipeda. In 2024, Belarus exported potash via several Russian ports. It also sent shipments by rail, primarily to China.

World annual potash production capacity was 65.2 million tons in 2024 and projected to increase to about 76.0 million tons of K_2O by 2028. Most of the increase would be MOP from new mines and expansion projects in Laos and Russia. New MOP mines in Belarus, Brazil, Canada, Ethiopia, Morocco, and Spain were planned to begin operation past 2028.

World Mine Production and Reserves: Reserves for Laos, Russia, and Spain were revised based on Government reports.

	Mine production		Reserves[5]	
	2023	2024[e]	Recoverable ore	K_2O equivalent
United States[1]	390	420	970,000	220,000
Belarus	[e]4,500	7,000	3,300,000	750,000
Brazil	[e]300	360	10,000	2,300
Canada	13,500	15,000	4,500,000	1,100,000
Chile	[e]600	750	NA	100,000
China	[e]6,000	6,300	NA	180,000
Germany	[e]2,700	3,000	NA	150,000
Israel	2,330	2,400	NA	[6]Large
Jordan	1,700	1,800	NA	[6]Large
Laos	[e]1,500	1,500	NA	1,000,000
Russia	[e]9,000	9,000	NA	920,000
Spain	367	400	NA	100,000
Other countries	435	440	1,500,000	300,000
World total (rounded)	43,300	48,000	>10,000,000	>4,800,000

World Resources:[5] Estimated domestic potash resources total about 7 billion tons. Most of these lie at depths between 1,800 and 3,100 meters in a 3,110-square-kilometer area of Montana and North Dakota as an extension of the Williston Basin deposits in Manitoba and Saskatchewan, Canada. The Paradox Basin in Utah contains resources of about 2 billion tons, mostly at depths of more than 1,200 meters. The Holbrook Basin of Arizona contains resources of about 0.7 billion to 2.5 billion tons. A large potash resource lies about 2,100 meters under central Michigan and contains more than 75 million tons. Estimated world resources total about 250 billion tons.

Substitutes: No substitutes exist for potassium as an essential plant nutrient and as an essential nutritional requirement for animals and humans. Manure and glauconite (greensand) are low-potassium-content materials that can be profitably transported only short distances to crop fields. Glauconite is used as a potassium source for organic farming.

[e]Estimated. NA Not available.
[1]Data are rounded to no more than two significant digits to avoid disclosing company proprietary data.
[2]Defined as sales + imports – exports.
[3]Includes MOP, SOP, and SOPM. Does not include other chemical compounds that contain potassium.
[4]Defined as imports – exports.
[5]See Appendix C for resource and reserve definitions and information concerning data sources.
[6]Israel and Jordan recover potash from the Dead Sea, which contains nearly 2 billion tons of potassium chloride.

PUMICE AND PUMICITE

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: In 2024, 10 operations in five States produced pumice and pumicite. Estimated production[1] was 450,000 tons with an estimated processed value of $19 million, free on board (f.o.b.) plant. That represented an increase in both quantity and value from the 2023 reported production of 438,000 tons valued at $18 million. Pumice and pumicite were mined in California, Idaho, Kansas, New Mexico, and Oregon. The porous, lightweight properties of pumice are well suited for its main uses. Mined pumice was used in the production of abrasives, concrete admixtures and aggregates, lightweight building blocks, horticultural purposes, and other uses, including absorbent, filtration, laundry stone washing, and road use.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, mine[1]	578	504	295	438	450
Imports for consumption	90	87	102	53	120
Exports	8	11	14	11	12
Consumption, apparent[2]	660	580	383	480	560
Price, average unit value, f.o.b. mine or mill, dollars per metric ton	31	46	65	41	42
Employment, mine and mill, number	140	140	140	140	140
Net import reliance[3] as a percentage of apparent consumption	12	13	23	9	19

Recycling: Little to no known recycling.

Import Sources (2020–23): Greece, 87%; Iceland, 8%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Pumice, crude or in irregular pieces, including crushed	2513.10.0010	Free.
Pumice, other	2513.10.0080	Free.

Depletion Allowance: 5% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The amount of domestically produced pumice and pumicite sold or used in 2024 was estimated to be 3% more than that in 2023. Imports and exports were estimated to have increased compared with those in 2023. An estimated 91% of all imported pumice originated from Greece in 2024 and primarily supplied markets in the eastern and gulf coast regions of the United States.

Pumice and pumicite are plentiful in the Western States, but legal challenges and public land designations could limit access to known deposits. Production of pumice and pumicite is sensitive to mining and transportation costs.

All known domestic pumice and pumicite mining in 2024 was accomplished through open pit methods, generally in remote areas away from major population centers. Although the generation and disposal of reject fines in mining and milling may result in local dust issues at some operations, such environmental impacts were estimated to be restricted to small geographic areas.

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PUMICE AND PUMICITE

World production of pumice and related material was estimated to be 18 million tons (rounded) in 2024, which was 3% more than that in 2023. Turkey was the leading global producer of pumice and pumicite, followed by Greece. Pumice is used more extensively as a building material outside the United States, which explained the large global production of pumice relative to that of the United States. In Europe, basic home construction uses stone and concrete as the preferred building materials. Prefabricated lightweight concrete walls, which may contain pumice as lightweight aggregate, are often produced and shipped to construction locations. Because of their cementitious properties, light weight, and strength, pumice and pumicite perform well in European-style construction.

World Mine Production and Reserves:

	Mine production[e]		Reserves[4]
	2023	2024	
United States[1]	[5]438	450	Large in the United States. Quantitative estimates of reserves for most countries were not available.
Algeria[6]	900	900	
Cameroon[6]	280	280	
Chile[6]	730	730	
Ecuador	800	800	
Ethiopia	510	510	
France[6]	280	280	
Greece[6]	1,010	1,000	
Guatemala	570	570	
Saudi Arabia[6]	980	980	
Spain	240	240	
Tanzania[6]	230	230	
Turkey	8,200	8,200	
Uganda[6]	830	830	
Other countries[6]	1,500	2,000	
World total (rounded)	17,500	18,000	

World Resources:[4] The identified U.S. resources of pumice and pumicite, estimated to be more than 25 million tons, are concentrated in the Western States. The estimated total resources (identified and undiscovered) in the Western and Great Plains States are at least 250 million tons and may total more than 1 billion tons. Large resources of pumice and pumicite have been identified on all continents.

Substitutes: The costs of transportation determine the maximum economic distance pumice and pumicite can be shipped and still remain competitive with alternative materials. Competitive materials that may be substituted for pumice and pumicite include crushed aggregates, diatomite, expanded shale and clay, and vermiculite.

[e]Estimated.
[1]Quantity sold and used by producers.
[2]Defined as production + imports – exports.
[3]Defined as imports – exports.
[4]See Appendix C for resource and reserve definitions and information concerning data sources.
[5]Reported.
[6]Includes pozzolan and (or) volcanic tuff.

QUARTZ (HIGH-PURITY AND INDUSTRIAL CULTURED CRYSTAL)

(Data in metric tons unless otherwise specified)

Domestic Production and Use: Ground high-purity quartz (HPQ) is typically defined as ground natural quartz with less than 100 parts per million of impurities and has further defined standards for the concentrations of specific impurities allowed. HPQ has specialized end uses including electronics, fiber optic cables, fused quartz crucibles (for manufacturing silicon metal ingots that are later processed into silicon wafers for the photovoltaic cell and semiconductor markets), high-temperature lamp tubing, and specialty glass. In 2024, there were two companies that produced HPQ in the United States around Spruce Pine, NC. The HPQ in Spruce Pine was sourced from pegmatite rocks that were concurrently mined to produce feldspar and mica. The pegmatite rocks were processed through a number of procedures which include being crushed, washed and scrubbed, and sorted. Additional processing for the HPQ included being physically processed, chemically processed, and thermally processed. At least one of these companies sent their product overseas for further processing.

Industrial cultured quartz crystal is electronic-grade quartz crystal that is manufactured, not mined. In the past, cultured quartz crystal was primarily produced using lascas[1] as raw quartz feed material. Lascas mining and processing in Arkansas ended in 1997. In 2024, two companies produced cultured quartz crystal in the United States. However, production data were withheld in order to avoid disclosing company proprietary data. In addition to lascas, these companies may use cultured quartz crystal that has been rejected during the manufacturing process, owing to crystallographic imperfections, as feed material. The companies likely use a mix of cultured quartz and imported lascas as feed material. In the past several years, cultured quartz crystal has been increasingly produced overseas, primarily in Asia. Electronic applications accounted for most industrial uses of quartz crystal; other uses included special optical applications. Virtually all quartz crystal used for electronics was cultured, rather than natural, crystal. Electronic-grade quartz crystal is used to make frequency controls, frequency filters, and timers in electronic circuits employed for a wide range of products, such as communications equipment, computers, and many consumer goods, such as electronic games and television receivers.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Ground high-purity quartz:					
Sold or used[e, 2]	100,000	100,000	200,000	200,000	200,000
Imports[3]	NA	NA	NA	NA	NA
Exports[3]	NA	NA	NA	NA	NA
Price, range of value, dollars per metric ton[e, 4, 5]	500–15,000	500–16,000	500–17,000	500–20,000	500–17,000
Net import reliance[6] as a percentage of apparent consumption	NA	NA	NA	NA	NA
Industrial cultured quartz crystal:					
Sold or used	W	W	W	W	W
Imports, piezoelectric	114	69	76	87	120
Exports, piezoelectric	37	39	76	133	100
Price, as-grown cultured quartz, dollars per kilogram[e, 4]	100	100	100	200	200
Price, lumbered quartz, dollars per kilogram[e, 4, 7]	400	300	300	400	500
Net import reliance[6] as a percentage of apparent consumption	NA	NA	NA	NA	NA

Recycling: An unspecified amount of rejected cultured quartz crystal was used as feed material for the production of cultured quartz crystal.

Import Sources (2020–23): Import statistics specific to lascas and HPQ were not available because they were combined with other types of quartz. Cultured quartz crystal (piezoelectric quartz, unmounted): China,[8] 89%; Denmark and Japan, 3% each; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Sand containing 95% or more silica and not more than 0.6% iron oxide (including HPQ)	2505.10.1000	Free.
Quartz (including lascas and HPQ)	2506.10.0050	Free.
Piezoelectric quartz, unmounted	7104.10.0000	3% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

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QUARTZ (HIGH-PURITY AND INDUSTRIAL CULTURED QUARTZ)

Government Stockpile:[9]

	FY 2024		FY 2025	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Quartz crystal, kilograms	—	7,148	—	7,127

Events, Trends, and Issues: Increased global manufacturing of silicon metal ingots that are later processed into silicon wafers for the photovoltaic cell and semiconductor markets has increased the demand for HPQ needed to make fused quartz crucibles. Growth of the electronics, fiber optic, and specialty glass markets are also likely to remain a factor in sustaining and increasing global demand for HPQ. Both HPQ companies in the United States continued capacity expansion plans.

On September 26, both HPQ companies in the United States shut down operations temporarily owing to Hurricane Helene. After the hurricane, there was minor damage to both companies' operations, and both companies were able to ramp up to full capacity and resume shipments from their operations in October.

Increased trade of piezoelectric quartz in the past several years was likely the result of increased demand for frequency-control oscillators and vibration sensors for aerospace, automotive, and telecommunication applications. Growth of the consumer electronics market (for example, communications equipment, electronic games, personal computers, and tablet computers) is also likely to remain a factor in sustaining global demand for cultured quartz crystal.

World Mine Production and Reserves:[10] This information was not available. Global reserves of HPQ were estimated to be limited to a few locations. The United States was estimated to be the leader in production of HPQ with other sources being Australia, Brazil, Canada, China, India, and Russia. The global reserves for lascas were estimated to be large. The majority of lascas was mined in Brazil and Madagascar.

World Resources:[10] Limited resources of HPQ exist throughout the world. Limited resources of natural quartz crystal suitable for direct electronic or optical use exist throughout the world. World dependence on natural quartz crystal resources will continue to decline because of the increased acceptance of cultured quartz crystal as an alternative material. Additionally, techniques using rejected cultured quartz crystal as feed material may result in decreased dependence on lascas for growing cultured quartz.

Substitutes: No economic substitutes or alternatives for HPQ exist for most applications. Cultured quartz can be used as a substitute for HPQ, although it is not commonly done owing to the high price of cultured quartz.

Silicon is increasingly being used as a substitute for quartz crystal for frequency-control oscillators in electronic circuits. Other materials, such as aluminum orthophosphate (the very rare mineral berlinite), langasite, lithium niobate, and lithium tantalate, which have larger piezoelectric coupling constants, have been studied and used. Centrosymmetric materials that have induced piezoelectricity have also been studied. The cost competitiveness of these materials, as opposed to cultured quartz crystal, is dependent on the type of application that the material is used for, and the processing required.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Lascas is a nonelectronic-grade quartz used as a feedstock for growing cultured quartz crystal and for production of fused quartz. Lascas data are not included in this publication.
[2]Production is estimated from a combination of publicly available data, published sources, and industry trends. Data are rounded to the nearest 100,000 metric tons to avoid disclosing company proprietary data.
[3]Trade data for ground high-purity quartz are included in Harmonized Tariff Schedule of the United States (HTS) codes 2505.10.1000 and 2505.10.1050 but are mixed with other types of sand and quartz. A reliable estimate cannot be made.
[4]Price is estimated from a combination of reported prices, trade data prices, and industry trends.
[5]Prices vary based on the percentage of quartz, percentage and type of impurities, and end use of the ground high-purity quartz.
[6]Defined as imports – exports.
[7]As-grown cultured quartz that has been processed by sawing and grinding.
[8]Includes Hong Kong.
[9]See Appendix B for definitions.
[10]See Appendix C for resource and reserve definitions and information concerning data sources.

RARE EARTHS[1]

[Data in metric tons, rare-earth-oxide (REO) equivalent, unless otherwise specified]

Domestic Production and Use: Rare earths were mined and processed domestically in 2024. An estimated 45,000 tons of REO in mineral concentrates were produced and were valued at $260 million. Bastnaesite (or bastnäsite), a rare-earth fluorocarbonate mineral, was mined as a primary product at a mine in Mountain Pass, CA. Monazite, a phosphate mineral, was stockpiled as a separated concentrate or included as an accessory mineral in heavy-mineral-sand concentrates in the southeastern United States. Mixed rare-earth compounds also were produced in the Western United States. The estimated value of rare-earth compounds and metals imported by the United States in 2024 was $170 million, an 11% decrease from $186 million in 2023. The estimated leading domestic end use of rare earths was catalysts. Significant amounts of rare earths are imported as permanent magnets embedded in finished goods. Other end uses were ceramics and glass, metallurgical applications and alloys, and polishing.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:[e]					
Mineral concentrates[2]	39,000	42,400	42,500	41,600	45,000
Compounds and metals[3]	—	120	95	250	1,300
Imports:[e, 4]					
Compounds	6,510	7,690	10,700	8,920	8,000
Metals:					
Ferrocerium, alloys	270	330	395	259	220
Rare-earth metals, scandium, and yttrium	363	580	487	476	90
Exports:[e, 4]					
Ores and compounds	40,000	44,200	45,900	20,700	43,000
Metals:					
Ferrocerium, alloys	626	825	1,520	817	1,100
Rare-earth metals, scandium, and yttrium	25	20	24	63	320
Consumption, apparent, compounds and metals[5]	6,490	7,900	10,200	10,100	6,600
Price, average, dollars per kilogram:[6]					
Cerium oxide, 99.5% minimum	2	2	1	1	1
Dysprosium oxide, 99.5% minimum	261	410	382	330	260
Europium oxide, 99.99% minimum	31	31	30	27	27
Lanthanum oxide, 99.5% minimum	2	2	1	1	1
Mischmetal, 65% cerium, 35% lanthanum	5	6	7	5	5
Neodymium oxide, 99.5% minimum	49	98	134	78	56
Terbium oxide, 99.99% minimum	670	1,346	2,051	1,298	810
Employment, mine and mill, annual average, number	185	293	350	450	570
Net import reliance[7] as a percentage of apparent consumption:[8]					
Compounds and metals	100	>95	>95	>95	80
Mineral concentrates	E	E	E	E	E

Recycling: Limited quantities of rare earths were recovered from batteries, permanent magnets, and fluorescent lamps.

Import Sources (2020–23): Rare-earth compounds and metals: China,[9] 70%; Malaysia, 13%; Japan, 6%; Estonia, 5%; and other, 6%. Compounds and metals imported from Estonia, Japan, and Malaysia were derived from mineral concentrates and chemical intermediates produced in Australia, China, and elsewhere.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Rare-earth metals	2805.30.0000	5% ad valorem.
Cerium compounds	2846.10.0000	5.5% ad valorem.
Other rare-earth compounds:		
Oxides or chlorides	2846.90.2000	Free.
Carbonates	2846.90.8000	3.7% ad valorem.
Ferrocerium and other pyrophoric alloys	3606.90.3000	5.9% ad valorem.

Depletion Allowance: Monazite, 22% on thorium content and 14% on rare-earth content (domestic), 14% (foreign); bastnaesite and xenotime, 14% (domestic and foreign).

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RARE EARTHS

Government Stockpile:[10] In the addition to the materials listed below, the fiscal year (FY) 2024 and 2025 potential acquisitions included varying amounts of neodymium-praseodymium oxide, neodymium-iron-boron magnet block, and samarium-cobalt alloy.

	FY 2024		FY 2025	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Cerium	550	—	—	—
Lanthanum	1,300	—	1,100	—

Events, Trends, and Issues: Global mine production was estimated to have increased to 390,000 tons of REO equivalent largely owing to increased mining and processing in China, Nigeria, and Thailand.

World Mine Production and Reserves: Reserves for Russia, South Africa, the United States, and Vietnam were revised based on company and Government reports.

	Mine production[e]		Reserves[11]
	2023	2024	
United States	41,600	45,000	1,900,000
Australia	[12]16,000	[12]13,000	[13]5,700,000
Brazil	140	20	21,000,000
Burma	[12]43,000	[12]31,000	NA
Canada	—	—	830,000
China	[14]255,000	[14]270,000	44,000,000
Greenland	—	—	1,500,000
India	2,900	2,900	6,900,000
Madagascar	[12]2,100	[12]2,000	NA
Malaysia	[12]310	[12]130	NA
Nigeria	[12]7,200	[12]13,000	NA
Russia	2,500	2,500	3,800,000
South Africa	—	—	860,000
Tanzania	—	—	890,000
Thailand	[12]3,600	[12]13,000	4,500
Vietnam	[12]300	[12]300	3,500,000
Other	1,440	1,100	NA
World total (rounded)	376,000	390,000	>90,000,000

World Resources:[10] Rare earths are relatively abundant in the Earth's crust, but minable concentrations are less common than for most other mineral commodities. In North America, measured and indicated resources of rare earths were estimated to include 3.6 million tons in the United States and more than 14 million tons in Canada.

Substitutes: Substitutes are available for many applications but generally are less effective.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Data include lanthanides and yttrium but exclude most scandium. See also the Scandium and Yttrium chapters.
[2]Excludes monazite concentrates for 2021–24.
[3]In 2023 and 2024, reported production includes that for praseodymium and neodymium compounds in California and rare-earth compounds in Utah. Other rare-earth compounds were produced in California, but data were not in the reported totals shown. Total domestic production in 2023 and 2024 was 1,920 tons and 7,600 tons, respectively.
[4]REO equivalent or content of various materials were estimated. Source: U.S. Census Bureau.
[5]Defined as production + imports – exports.
[6]Source: Argus Media Group, Argus Non-Ferrous Markets.
[7]Defined as imports – exports.
[8]In 2020, all domestic production of mineral concentrates was exported or held in inventory, and all compounds and metals consumed were assumed to be imported material.
[9]Includes Hong Kong.
[10]Gross weight. See Appendix B for definitions.
[11]See Appendix C for resource and reserve definitions and information concerning data sources.
[12]Estimated based on reported import data for China. Source: Zen Innovations, Global Trade Tracker.
[13]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 3.3 million tons.
[14]Production quota; does not include undocumented production.

RHENIUM

(Data in kilograms, rhenium content, unless otherwise specified)

Domestic Production and Use: During 2024, rhenium-containing products including ammonium perrhenate (APR), metal powder, and perrhenic acid were produced as byproducts from roasting molybdenum concentrates from porphyry copper-molybdenum deposits in Arizona and Montana. Total estimated U.S. primary production was approximately 9,500 kilograms in 2024, compared with 9,410 kilograms in 2023. The United States continued to be a leading producer of secondary rhenium, recovering rhenium from nickel-base superalloy scrap, spent oil-refining catalysts, and foundry revert. The major uses of rhenium were in superalloys used in high-temperature turbine engine components and in petroleum-reforming catalysts, representing an estimated 80% and 15%, respectively, of end uses. Bimetallic platinum-rhenium catalysts were used in petroleum reforming to produce high-octane hydrocarbons, which are used in the production of lead-free gasoline. Rhenium improves the high-temperature (>1,000 degrees Celsius) strength properties of some nickel-base superalloys. Rhenium alloys were used in crucibles, electrical contacts, electromagnets, electron tubes and targets, heating elements, ionization gauges, mass spectrographs, metallic coatings, semiconductors, temperature controls, thermocouples, vacuum tubes, and other applications.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production[1]	8,830	9,290	8,870	9,410	9,500
Imports for consumption					
Rhenium, unwrought and powders[2]	15,900	15,900	11,900	10,200	13,000
Ammonium perrhenate[3]	9,320	6,020	8,810	4,890	6,900
Exports	—	—	267	2,010	2,200
Consumption, apparent[4]	34,000	31,200	29,400	22,500	27,000
Price, average value, gross weight, dollars per kilogram:[5]					
Metal pellets, 99.99% pure	1,030	977	1,120	1,070	1,370
Ammonium perrhenate	1,090	866	911	920	1,270
Employment, number	Small	Small	Small	Small	Small
Net import reliance[6] as a percentage of apparent consumption	74	70	70	58	65

Recycling: Nickel-base superalloy scrap and scrapped turbine blades and vanes continued to be recycled hydrometallurgically to produce rhenium metal for use in new superalloy melts. The scrapped parts also were processed to generate engine revert—a high-quality, lower cost superalloy meltstock—by an increasing number of companies, mainly in Canada, Estonia, France, Germany, Japan, Poland, Russia, and the United States. Rhenium-containing catalysts also were recycled. The rhenium recycled from spent catalysts was either returned to the oil companies or to the catalyst producer for production of new catalysts in what is considered a closed-loop system.

Import Sources (2020–23): Ammonium perrhenate: Kazakhstan, 26%; Canada, 24%; Poland, 15%; and other, 35%. Rhenium metal powder: Chile, 62%; Germany, 15%; Canada, 12%; Poland, 7%; and other, 4%. Total imports: Chile, 44%; Canada, 16%; Germany, 13%; Poland, 10%; and other, 17%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Salts of peroxometallic acids, other, ammonium perrhenate	2841.90.2000	3.1% ad valorem.
Rhenium, unwrought, waste and scrap	8112.41.1000	Free.
Rhenium, unwrought, powders	8112.41.5000	3% ad valorem.
Rhenium, other	8112.49.0000	4% ad valorem.
Rhenium (and other metals), wrought	8112.99.9100	4% ad valorem.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

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RHENIUM

Events, Trends, and Issues: In 2024, the estimated price for catalytic-grade APR averaged $1,270 per kilogram, 38% more than the annual average price of $920 per kilogram in 2023. The estimated rhenium metal pellet price averaged $1,370 per kilogram in 2024, a 28% increase from the annual average price of $1,070 per kilogram in 2023.

In 2024, apparent consumption in the United States was about 20% more than that in 2023. During 2024, the United States continued to rely on imports for much of its supply of rhenium. Canada, Chile, Germany, Kazakhstan, and Poland supplied most of the imported rhenium. Imports of APR increased by an estimated 41% in 2024 compared with those in 2023. Imports of rhenium metal increased by an estimated 25% in 2024 compared with those in 2023. Estimated world rhenium production in 2024 was 62,000 kilograms compared with 62,600 kilograms in 2023.

The United States and Germany continued to be the leading secondary rhenium producers. Secondary rhenium production also took place in Canada, Estonia, France, Japan, Poland, and Russia. Available information was insufficient to make U.S. secondary production estimates; however, industry sources estimated that U.S. capacity was between 18,000 and 20,000 kilograms per year of rhenium. Industry sources estimated that approximately 25,000 kilograms of secondary rhenium was produced worldwide in 2024.

World Mine Production and Reserves:

	Mine production[e, 7]		Reserves[8]
	2023	2024	
United States	9,410	9,500	400,000
Armenia	210	200	95,000
Chile[9]	30,000	29,000	1,300,000
China	5,300	5,300	19,000
Kazakhstan	500	500	190,000
Korea, Republic of	2,800	3,000	NA
Poland	9,380	9,400	NA
Russia	NA	NA	310,000
Uzbekistan	5,000	5,000	NA
World total (rounded)	62,600	62,000	Large

World Resources:[8] Most rhenium occurs with molybdenum in porphyry copper deposits. Identified U.S. resources are estimated to be about 7 million kilograms. Rhenium also is associated with copper minerals in sedimentary deposits in Armenia, Kazakhstan, Poland, Russia, and Uzbekistan, where ore is processed for copper recovery and the rhenium-bearing residues are recovered at copper smelters.

Substitutes: Substitutes for rhenium in platinum-rhenium catalysts are continually being evaluated; one such application using iridium and tin has achieved commercial success. Other metals being evaluated for catalytic use include gallium, germanium, indium, selenium, silicon, tungsten, and vanadium. The use of these and other metals in bimetallic catalysts might decrease rhenium's share of the existing catalyst market; however, this would likely be offset by rhenium-bearing catalysts being considered for use in several proposed gas-to-liquid projects. Materials that can substitute for rhenium in various end uses are as follows: cobalt and tungsten for coatings on copper X-ray targets, rhodium and rhodium-iridium for high-temperature thermocouples, tungsten and platinum-ruthenium for coatings on electrical contacts, and tungsten and tantalum for electron emitters.

[e]Estimated. NA Not available. — Zero.
[1]Based on 80% recovery of estimated rhenium contained in molybdenum disulfide concentrates. Secondary rhenium production not included.
[2]Includes data for the following Harmonized Tariff Schedule of the United States (HTS) codes: 8112.92.5000 (2020–21) and 8112.41.5000 and 8112.49.0000 (2022–24). Does not include wrought forms or waste and scrap.
[3]The rhenium content of ammonium perrhenate is 69.42%.
[4]Defined as production + imports – exports.
[5]Average price per kilogram of rhenium in pellets or catalytic-grade ammonium perrhenate. Source: Argus Media Group, Argus Non-Ferrous Markets.
[6]Defined as imports – exports.
[7]Estimated amount of rhenium recovered in association with copper and molybdenum production. Secondary rhenium production not included.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.
[9]Estimated rhenium recovered from roaster residues from Belgium, Chile, Mexico, and Peru.

RUBIDIUM

(Data in metric tons, rubidium oxide, unless otherwise specified)

Domestic Production and Use: In 2024, no rubidium was mined in the United States; however, occurrences of rubidium-bearing minerals are known in Alaska, Arizona, Idaho, Maine, South Dakota, and Utah. Rubidium is also associated with some evaporate mineral occurrences in other States. Rubidium is not a major constituent of any mineral. Rubidium concentrate is produced as a byproduct of pollucite (cesium) and lepidolite (lithium) mining and is imported from other countries for processing in the United States.

Applications for rubidium and its compounds include biomedical research, electronics, pyrotechnics, and specialty glass. Specialty glasses are the leading market for rubidium; rubidium carbonate may be used to reduce electrical conductivity, which improves stability and durability in fiber-optic telecommunications networks. Biomedical applications may include rubidium salts used in antishock agents and the treatment of epilepsy and thyroid disorder; rubidium-82, a radioactive isotope, may be used as a blood-flow tracer in positron emission tomographic imaging; and rubidium chloride may be used as an antidepressant.

Rubidium's photoemissive properties make it useful for electrical-signal generators in motion-sensor devices, night-vision devices, photoelectric cells (solar panels), spectrometers, magnetometers, and photomultiplier tubes. For industrial uses, rubidium is widely used as a catalyst in ammonia synthesis, hydrogenation, oxidation and polymerization reactions, and sulfuric acid synthesis. Rubidium may be used as an atomic resonance-frequency-reference oscillator for telecommunications network synchronization, playing a vital role in global positioning systems. Rubidium-rich feldspars may be used in ceramic applications for spark plugs and electrical insulators because of their high dielectric constant. Rubidium hydroxide may be used in fireworks to oxidize mixtures of other elements and produce violet hues. The U.S. military frequency standard, the United States Naval Observatory (USNO) timescale, is based on a network of weighted atomic clocks, including 6 USNO rubidium fountain clocks.

Rubidium atoms are used in academic research, including the development of quantum-mechanics-based computing devices, a future application with potential for relatively high consumption of rubidium. Quantum computing, which uses ultracold rubidium atoms in a variety of applications in research, would perform more complex computational tasks than traditional computers by calculating in two quantum states simultaneously. Research suggests that rubidium may be used in chemical storage within hydrogen batteries, ion propulsion engines, magnetohydrodynamic power generation, and thermionic power conversion.

Salient Statistics—United States: Consumption, export, and import data were not available. Some concentrate was imported to the United States in prior years for further processing. Industry information during the past decade suggests a domestic consumption rate of less than 2,000 kilograms per year. The United States was 100% import reliant for rubidium minerals.

At the end of September 2024, one company offered 1-gram ampoules of 99.75% (metal basis) rubidium for $128.00, a 6% increase from $121.00 in 2023, and 100-gram ampoules of the same material for $2,290, a 6% increase from $2,160.00 in 2023. The price for 10-gram ampoules of 99.8% (metal basis) rubidium formate hydrate was $302.00, a 4% increase from $290.00 in 2023. One company cited the price for rubidium carbonate was $1,244.19 per kilogram, value-added tax included, at the end of September 2024.

In 2024, the prices for 10 grams of 99.8% (metal basis) rubidium acetate, rubidium bromide, rubidium carbonate, rubidium chloride, and rubidium nitrate were $68.70, $97.40, $66.30, $84.10, and $62.60, respectively, with increases ranging from 4% to 5% compared with prices in 2023.

The price for a rubidium-plasma standard solution (10,000 micrograms per milliliter) was $67.70 for 50 milliliters and $119.00 for 100 milliliters, an increase of 4% and 3%, respectively, from those in 2023.

Recycling: None.

Import Sources (2020–23): No reliable data have been available to determine the source of rubidium ore or compounds imported by the United States since 1988. The United States was 100% net import reliant for its rubidium needs and the primary global producers, including refined rubidium compounds, were estimated to include China, Germany, and Russia.

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RUBIDIUM

Tariff: Item	Number	Normal Trade Relations 12–31–24
Alkali metals, other	2805.19.9000	5.5% ad valorem.
Chlorides, other	2827.39.9000	3.7% ad valorem.
Bromides, other	2827.59.5100	3.6% ad valorem.
Iodides, other	2827.60.5100	4.2% ad valorem.
Sulfates, other	2833.29.5100	3.7% ad valorem.
Nitrates, other	2834.29.5100	3.5% ad valorem.
Carbonates, other	2836.99.5000	3.7% ad valorem.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic rubidium occurrences will remain subeconomic unless market conditions change, such as the development of new end uses or increased consumption for existing end uses, which in turn could lead to increased prices. No known human health issues are associated with exposure to naturally occurring rubidium, and its use has minimal environmental impact.

During 2024, no rubidium production was reported globally but rubidium may have been produced in China. Known production of rubidium ore from all countries, excluding China, ceased within the past two decades. Mining of rubidium in Namibia ceased in the early 2000s. The Bikita Mine in Zimbabwe was depleted of pollucite ore reserves in 2018. The Sinclair Mine in Australia completed the mining and shipments of all economically recoverable pollucite ore in 2019. Recent reports indicate that with current processing rates, the world's commercial stockpiles of rubidium ore, excluding those in China, may be depleted in the near future.

Throughout 2024, multiple projects that could produce rubidium as a byproduct of lepidolite, pollucite, spodumene, or zinnwaldite mining, focused primarily on lithium or cesium extraction, were in the exploration and feasibility stages. One company continued developing a lepidolite concentration mine and processing facility in Namibia, with a targeted lithium hydroxide capacity of 5,700 tons per year expected to commence operations in 2026. Byproduct rubidium production was expected to be sent to a downstream chemical conversion facility in Abu Dhabi. In August 2024, another company announced that the Mount Edon Project in Western Australia had an initial Joint Ore Reserves Committee-compliant inferred mineral resource estimate totaling 3.6 million tons, which contained an estimated 7,900 tons of rubidium oxide, and planned to develop a mining proposal by yearend 2025.

World Mine Production and Reserves:[1] There were no official sources for rubidium production data in 2024. Lepidolite and pollucite, the principal rubidium-containing minerals in global rubidium reserves, can contain up to 3.5% and 1.5% rubidium oxide, respectively. Rubidium-bearing mineral resources are found in zoned pegmatites. Mineral resources exist globally, but extraction and concentration are mostly cost prohibitive. No reliable data were available to determine reserves for specific countries; however, Australia, Canada, China, and Namibia were estimated to have reserves totaling less than 200,000 tons of recoverable rubidium materials. Existing stockpiles at multiple former mine sites have continued feeding downstream refineries.

World Resources:[1] Significant rubidium-bearing pegmatite occurrences have been identified in Afghanistan, Australia, Canada, China, Denmark, Germany, Japan, Kazakhstan, Namibia, Peru, Russia, the United Kingdom, the United States, and Zambia. Minor quantities of rubidium are reported in brines in northern Chile and China and in evaporites in the United States (New Mexico and Utah), France, and Germany.

Substitutes: Rubidium and cesium can be used interchangeably in many applications because they have similar physical properties and atomic radii. Cesium, however, is more electropositive than rubidium, making it a preferred material for some applications.

[1]See Appendix C for resource and reserve definitions and information concerning data sources.

SALT

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: Domestic production of salt was an estimated 40 million tons in 2024. The quantity of salt sold or used in 2024 was an estimated 39 million tons with a total estimated value of $2.5 billion. Salt was produced by 26 companies that operated 64 plants in 16 States. The top producing States were Kansas, Louisiana, Michigan, New York, Ohio, Texas, and Utah. These seven States produced about 95% of the salt in the United States in 2024. The estimated percentage of salt sold or used was, by type, salt in brine, 42%; rock salt, 40%; solar salt, 9%; and vacuum pan salt, 9%.

Highway deicing accounted for about 41% of total salt consumed. The chemical industry accounted for about 39% of total salt sales, with salt in brine accounting for 91% of the salt used for chemical feedstock. Chlorine and caustic soda manufacturers were the main consumers within the chemical industry. The remaining markets for salt were distributors, 9%; food processing, 4%; agricultural, 3%; general industrial, 2%; primary water treatment, 1%; and miscellaneous, 1%.

Salient Statistics—United States:[1]	2020	2021	2022	2023	2024[e]
Production	42,600	39,300	39,400	[e]42,000	40,000
Sold or used by producers	39,600	39,800	40,600	[e]41,000	39,000
Imports for consumption	15,800	17,700	18,300	15,700	14,000
Exports	1,250	1,010	886	2,260	1,900
Consumption:					
Apparent[2]	54,200	56,400	58,000	[e]54,000	51,000
Reported	44,000	47,100	45,300	[e]45,000	43,000
Price, average unit value of bulk, pellets and packaged salt, free on board (f.o.b.) mine and plant, dollars per metric ton:					
Vacuum and open pan salt	212.21	203.72	217.58	[e]220	230
Solar salt	122.77	153.52	128.87	[e]140	140
Rock salt	61.71	59.88	56.86	[e]56	56
Salt in brine	8.36	8.14	9.11	[e]9	10
Employment, mine and plant, number[e]	4,000	4,000	4,100	4,100	4,100
Net import reliance[3] as a percentage of apparent consumption	27	30	30	25	24

Recycling: None.

Import Sources (2020–23): Canada, 29%; Chile, 27%; Mexico, 14%; Egypt, 8%; and other, 22%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Salt (sodium chloride)	2501.00.0000	Free.

Depletion Allowance: 10% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Consumption of salt in 2024 decreased compared with consumption in recent years as road salt use declined. Increased energy costs resulted in increased processing and especially transportation costs which negatively affected the ability to import and export salt at competitive prices for some international transactions.

For much of the 2023–24 winter, temperatures were near or above average with lower or average precipitation throughout most of the traditional U.S. snowbelt. The number of winter weather events including freezing rain, sleet, and snow is a better predictor of demand for rock salt than total snowfall. Several low snowfall or icing events usually require more salt for highway deicing than a single large snowfall event. Rock salt imports in 2024 were estimated to have decreased compared with those in 2023 because consumption by many local and State transportation departments was slightly less or unchanged from the previous year and stockpiles of domestically sourced salt were sufficient to meet demand in many areas.

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SALT

For the 2024–25 winter, the National Oceanic and Atmospheric Administration (NOAA) predicted a developing La Niña weather pattern. This historically favors storm tracks along the northern United States and a warmer-than-average temperature pattern in the southern tier of the continental United States. NOAA forecasted drier-than-average conditions for the Gulf Coast, the Southeast, and the Southwest but wetter-than-average conditions across the Great Lakes and Northwest regions of the United States. Much of the Great Plains, the Middle Atlantic, and the Northeast are expected to experience average precipitation amounts with a slight chance of warmer-than-average conditions. These forecasts indicate that demand for rock salt could increase slightly compared with that in previous season in some locales in the United States.

Demand for salt brine used in the chloralkali industry was expected to increase in 2024 as demand for caustic soda and polyvinyl chloride increases globally, especially in Asia. Salt exports from Australia and India have increased in recent years to meet the increasing demand.

World Production and Reserves:

	Mine production[e]		Reserves[4]
	2023	2024	
United States[1]	42,000	40,000	Large. Economic and subeconomic deposits of salt are substantial in principal salt-producing countries. The oceans contain a virtually inexhaustible supply of salt.
Australia	12,000	13,000	
Belarus	2,000	2,100	
Brazil	6,600	6,600	
Bulgaria	3,000	3,000	
Canada	12,000	12,000	
Chile	10,000	11,000	
China	54,000	55,000	
Egypt	2,300	2,300	
France	4,600	5,000	
Germany	15,000	16,000	
India	27,000	28,000	
Iran	2,700	2,700	
Italy	1,800	1,900	
Mexico	8,700	9,000	
Netherlands	5,300	6,000	
Pakistan	3,100	3,000	
Poland	4,500	4,600	
Russia	8,200	8,000	
Saudi Arabia	2,500	2,400	
Spain	3,900	4,000	
Turkey	9,100	9,000	
United Kingdom	2,700	2,800	
Other countries	27,000	28,000	
World total (rounded)	270,000	280,000	

World Resources:[4] World continental resources of salt are vast, and the salt content in the oceans is nearly unlimited. Domestic resources of rock salt and salt from brine are primarily in Kansas, Louisiana, Michigan, New York, Ohio, and Texas. Saline lakes and solar evaporation salt facilities are in Arizona, California, Nevada, New Mexico, Oklahoma, and Utah. Almost every country in the world has salt deposits or solar evaporation operations of various sizes.

Substitutes: No economic substitutes or alternatives for salt exist in most applications. Calcium chloride and calcium magnesium acetate, hydrochloric acid, and potassium chloride can be substituted for salt in deicing, certain chemical processes, and food flavoring, but at a higher cost.

[e]Estimated.
[1]Excludes production from Puerto Rico.
[2]Defined as sold or used by producers + imports – exports.
[3]Defined as imports – exports.
[4]See Appendix C for resource and reserve definitions and information concerning data sources.

SAND AND GRAVEL (CONSTRUCTION)[1]

(Data in million metric tons unless otherwise specified)

Domestic Production and Use: In 2024, an estimated 890 million tons of construction sand and gravel valued at $12 billion was produced by an estimated 3,400 companies operating 6,500 pits and more than 200 sales and (or) distribution yards in 50 States. Leading producing States were, in order of decreasing tonnage, California, Texas, Arizona, Minnesota, Michigan, Washington, Utah, Colorado, Idaho, and Wisconsin, which together accounted for about 53% of total output. An estimated 42% of construction sand and gravel was used as portland cement concrete aggregates, 20% for road base and coverings, 12% for construction fill, and 9% for asphaltic concrete aggregate and for other bituminous mixtures. The remaining amount was used for concrete products, drainage and rip rap, filtration, golf course maintenance, landscaping, masonry sand, pea gravel, pipe bending, plaster and gunite sands, railroad ballast, road stabilization, roofing granules, snow and ice control, and other miscellaneous uses.

The estimated output of construction sand and gravel in the United States shipped for consumption in the first 9 months of 2024 was 684 million tons, a decrease of 6% compared with that in the same period in 2023. Third-quarter shipments for consumption decreased by 8% compared with those in the same period in 2023. Additional production information, by quarter, for each State, geographic division, and the United States is reported by the U.S. Geological Survey in its quarterly Mineral Industry Surveys for construction sand and gravel and crushed stone.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Sold or used by producers	919	939	959	967	890
Imports for consumption	5	5	4	5	5
Exports	([2])	([2])	([2])	([2])	([2])
Consumption, apparent[3]	924	943	963	972	890
Price, average unit value, dollars per metric ton	9.95	10.52	11.35	12.54	13.90
Employment, mine and mill, number[4]	37,900	37,800	39,100	40,100	40,200
Net import reliance[5] as a percentage of apparent consumption	1	([2])	([2])	([2])	1

Recycling: Road surfaces made of asphalt concrete and portland cement concrete surface layers, which contain sand and gravel aggregate, were recycled on a limited but increasing basis in most States. In 2024, asphalt and portland cement concrete road surfaces were recycled in all 50 States.

Import Sources (2020–23): Canada, 93%; Mexico, 3%; and other, 4%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–24**
Sand, other	2505.90.0000	Free.
Pebbles and gravel	2517.10.0015	Free.

Depletion Allowance: Common varieties, 5% (domestic and foreign).

Government Stockpile: None.

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SAND AND GRAVEL (CONSTRUCTION)

Events, Trends, and Issues: U.S. construction sand and gravel production was about 890 million tons in 2024, a decrease of 8% compared with that in 2023. Apparent consumption also decreased to 890 million tons. Consumption of construction sand and gravel decreased in 2024 because of significant weather events and continued decreases in residential housing demand caused by interest rates continuing to be at some of the highest levels in 23 years. Usually, commercial and heavy-industrial construction activity, infrastructure funding, labor availability, new single-family housing unit starts, and weather affect growth in construction sand and gravel production and consumption. Long-term increases in construction aggregates demand are influenced by activity in the public and private construction sectors, as well as by construction work related to infrastructure improvements around the Nation.

The 2021 Infrastructure Investment and Jobs Act reauthorized surface transportation programs for 5 years and authorized investment of additional funding to repair roads and bridges and support major, transformational projects. The 2021 law authorized $1.2 trillion in funding and will expire at the end of the 2026 Federal fiscal year. The funding included $118 billion to the Highway Trust Fund—$90 billion to the highway account and $28 billion to the transit account. During the first 9 months of 2024, total highway construction spending was 8% more than that in the same period in 2023.

The underlying factors that would support an increase in prices for construction sand and gravel are expected to be present in 2025, especially in and near metropolitan areas. Shortages in some urban and industrialized areas are expected to continue to increase owing to local zoning regulations and land-development alternatives. These issues are expected to continue and to cause new construction sand and gravel pits to be located away from large population centers. Resultant regional shortages of construction sand and gravel and higher fuel costs could result in higher-than-average price increases in industrialized and urban areas.

The construction sand and gravel industry continued to address health and safety regulations, permitting and zoning issues, and environmental restrictions in 2024.

World Mine Production and Reserves:

	Mine production		Reserves[6]
	2023	2024[e]	
United States	967	890	Reserves are controlled largely by land use and (or) environmental concerns.
Other countries[7]	NA	NA	
World total	NA	NA	

World Resources:[6] Sand and gravel resources are plentiful throughout the world. However, because of environmental regulations, geographic distribution, and quality requirements for some uses, sand and gravel extraction is uneconomical in some cases. The most important commercial sources of sand and gravel have been glacial deposits, river channels, and river flood plains. Use of offshore deposits in the United States is mostly restricted to beach erosion control and replenishment. Other countries routinely mine offshore deposits of aggregates for onshore construction projects.

Substitutes: Crushed stone, the other major construction aggregate, is often substituted for natural sand and gravel, especially in more densely populated areas of the Eastern United States. Crushed stone remains the dominant choice for construction aggregate use. Increasingly, recycled asphalt and portland cement concretes are being substituted for virgin aggregate, although the percentage of total aggregate supplied by recycled materials remained very small in 2024.

[e]Estimated. NA Not available.
[1]See also the Sand and Gravel (Industrial) and the Stone (Crushed) chapters.
[2]Less than ½ unit.
[3]Defined as sold or used by producers + imports – exports.
[4]Including office staff. Source: Mine Safety and Health Administration.
[5]Defined as imports – exports.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]No reliable production information is available for most countries owing to the wide variety of ways in which countries report their sand and gravel production. Some countries do not report production for this mineral commodity. Production information for some countries is available in the U.S. Geological Survey Minerals Yearbook, volume III, Area Reports—International.

SAND AND GRAVEL (INDUSTRIAL)[1]

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: In 2024, industrial sand and gravel sold or used was an estimated 130 million tons valued at an estimated $5.1 billion. The quantity of industrial sand and gravel sold or used decreased slightly, and the value decreased by 12% compared with that in 2023. Industrial sand and gravel was produced by 133 companies from 216 operations in 33 States. The leading producing States were, in descending order of production, Texas, Wisconsin, Illinois, and Oklahoma. Combined production from these States accounted for 78% of total domestic sales and use. Approximately 83% of the U.S. tonnage was used as hydraulic-fracturing sand (frac sand) and well-packing and cementing sand, and 7% as glassmaking sand. Other common uses were, in decreasing quantity of use, foundry sand, whole grain fillers for building products, filtration sand, and recreational sand, which accounted for 6% combined. Other minor uses were, in decreasing quantity of use, roofing granules, chemicals, abrasives, silicon and ferrosilicon, ceramics, well packing and cementing sand, fillers, traction, filtration gravel, metallurgic flux, and other unspecified uses accounted for 4% combined.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Sold or used	75,800	91,200	121,000	133,000	130,000
Imports for consumption	417	350	338	211	300
Exports	4,090	5,440	6,390	7,160	8,300
Consumption, apparent[2]	72,100	86,200	115,000	126,000	120,000
Price, average value, dollars per metric ton	29.50	40.80	45.40	43.40	39
Employment, quarry and mill, number[e]	4,500	5,300	6,000	6,100	6,200
Net import reliance[3] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Recycled cullet (pieces of glass) represents a significant proportion of reused silica. About 33% of glass containers are recycled. Some abrasive and foundry sands are recycled or reclaimed.

Import Sources (2020–23): Canada, 85%; Vietnam, 4%; Brazil, 3%; Taiwan, 3%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Sand containing 95% or more silica and not more than 0.6% iron oxide	2505.10.1000	Free.

Depletion Allowance: Industrial sand or pebbles, 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: U.S. apparent consumption of industrial sand and gravel was estimated to be 120 million tons in 2024, a 5% decrease from that in 2023. The most important driving force in the industrial sand and gravel industry remained the production and sale of frac sand. In recent years, the consumption of frac sand increased as hydrocarbon extraction from shale deposits increased and the quantity of frac sand used per well increased in the United States. In 2024, industrial sand and gravel consumption decreased as an oversupply of frac sand led to lower prices, which caused many operations to decrease production or idle operations. Imports of industrial sand and gravel in 2024 were an estimated 300,000 tons, a 42% increase from those in 2023. U.S. exports of industrial sand and gravel were an estimated 8,300,000 tons, a 16% increase from those in 2023. The United States remained a net exporter of industrial sand and gravel. The weekly average active rig count[4] decreased by 15% in the first 9 months in 2024 compared with that in the same period in 2023 and remained 39% lower than that in the same period in 2019 before the global coronavirus disease 2019 (COVID-19) pandemic in 2020.

The United States was the world's leading producer and consumer of industrial sand and gravel based on estimated world production figures. Collecting definitive data on industrial sand and gravel production for most nations is difficult because of the wide range of terminology and specifications used by different countries. The United States remained a major exporter of industrial sand and gravel, shipping it to almost every region of the world. High global demand for U.S. industrial sand and gravel is attributed to its high quality and to the advanced processing techniques used in the United States for many grades of industrial sand and gravel, meeting specifications for virtually any use.

The industrial sand and gravel industry continued to be concerned with safety and health regulations and environmental restrictions in 2024, especially those concerning crystalline silica exposure. In April 2024, the Mine Safety and Health Administration published a final rule which amended its existing standards to protect miners against exposure to respirable crystalline silica.[5]

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SAND AND GRAVEL (INDUSTRIAL)

Local shortages of industrial sand and gravel were expected to continue to increase owing to land development priorities, local zoning regulations, and logistical issues. These factors may result in future sand and gravel operations being located farther from high-population centers. Increased efforts to reduce cost, emissions, and the risk of exposure to crystalline silica have led to an increase of in-basin "dry sand" and undried "wet sand" being sold or used as frac sand instead of conventional "dry sand" from out-of-basin sources.

In 2024, multiple companies that were top producers of industrial sand and gravel were acquired by or merged with other companies.

World Mine Production and Reserves:

	Mine production[e]		Reserves[6]
	2023	2024	
United States	[7]133,000	130,000	Large. Industrial sand and gravel deposits are widespread.
Argentina	4,000	4,000	
Australia	5,500	5,600	
Bulgaria	8,050	8,200	
Canada	4,100	4,100	
China	88,100	89,000	
France	[7]11,900	12,000	
Germany	11,100	11,000	
India	11,900	12,000	
Indonesia	3,540	3,500	
Italy	33,000	33,000	
Malaysia	7,000	7,000	
Mexico	2,700	2,700	
Netherlands	60,000	60,000	
Poland	5,930	5,900	
Russia	7,300	7,300	
Saudi Arabia	2,100	2,100	
Spain	6,600	6,000	
Turkey	[7]13,000	13,000	
United Kingdom	4,900	4,900	
Other countries	22,700	23,000	
World total (rounded)	446,000	440,000	

World Resources:[6] Sand and gravel resources of the world are large. However, because of their geographic distribution, environmental restrictions, and quality requirements for some uses, extraction of these resources is sometimes uneconomical. Quartz-rich sand and sandstone, the main sources of industrial silica sand, occur throughout the world.

Substitutes: Alternative materials that can be used for glassmaking, foundry, and molding sands are chromite, olivine, staurolite, and zircon sands. Alternative materials that can be used for abrasive sands are garnet, olivine, and slags. Although costlier and mostly used in deeper wells, alternative materials that can be used as proppants are sintered bauxite and kaolin-based ceramic proppants.

[e]Estimated. E Net exporter.
[1]See also the Sand and Gravel (Construction) chapter.
[2]Defined as production (sold or used) + imports – exports.
[3]Defined as imports – exports.
[4]Source: Baker Hughes Co., 2024, Rig count overview & summary count: Baker Hughes Co. (Accessed October 17, 2024, at https://rigcount.bakerhughes.com/na-rig-count.)
[5]Source: Mine Safety and Health Administration, 2024, Lowering miner's exposure to respirable crystalline silica and improving respiratory protection: Federal Register, v. 89, no. 76, April 18, p. 28218–28485. (Accessed November 21, 2024, at https://www.govinfo.gov/content/pkg/FR-2024-04-18/pdf/2024-06920.pdf.)
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]Reported.

SCANDIUM[1]

(Data in metric tons, scandium oxide equivalent, unless otherwise specified)

Domestic Production and Use: Domestically, scandium was neither mined nor recovered from process streams or mine tailings in 2024. Scandium was last produced domestically in 1969 primarily from the scandium-yttrium silicate mineral thortveitite and from byproduct leach solutions from uranium operations. Limited capacity to produce ingot and distilled scandium metal existed at facilities in Ames, IA; Tolleson, AZ; and Urbana, IL. The principal uses for scandium in 2024 were in aluminum-scandium alloys and solid oxide fuel cells (SOFCs). Other uses for scandium included ceramics, electronics, lasers, lighting, and radioactive isotopes. Global consumption has increased considerably driven by its use in SOFCs and aluminum alloys.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Price, yearend:					
Compounds, dollars per gram:					
Acetate, 99.9% purity, 5-gram lot size[2]	45	43	46	70	60
Chloride, 99.9% purity, 5-gram lot size[2]	133	137	140	166	157
Fluoride, 99.9% purity (99.99% purity in 2022; 2024), 1-gram lot size[3]	214	216	250	216	410
Iodide, 99.999% purity, 5-gram lot size[2]	161	161	170	200	208
Oxide, 99.99% purity, 5-kilogram lot size[4]	3.80	2.20	2.10	NA	1.20
Metal:					
Scandium, dollars per gram:[2]					
Distilled dendritic, 2-gram lot size	233	238	260	269	513
Ingot, 5-gram lot size	134	137	150	153	153
Scandium-aluminum alloy, dollars per kilogram:[4]					
1-kilogram lot size	340	350	350	NA	360
1,000-kilogram lot size	NA	NA	98	NA	32
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2020–23): Although there are no trade codes for scandium materials exclusively, shipping records indicated imported material was mostly from Japan, China, and Philippines.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Rare-earth metals:		
Unspecified, not alloys	2805.30.0050	5% ad valorem.
Unspecified, alloyed	2805.30.0090	5% ad valorem.
Compounds of rare-earth metals:		
Mixtures of oxides of yttrium or scandium as the predominant metal	2846.90.2015	Free.
Mixtures of chlorides of yttrium or scandium as the predominant metal	2846.90.2082	Free.
Mixtures of other rare-earth carbonates, including scandium	2846.90.8075	3.7% ad valorem.
Mixtures of other rare-earth compounds, including scandium	2846.90.8090	3.7% ad valorem.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

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SCANDIUM

Events, Trends, and Issues: In 2024, the global consumption of scandium oxide was estimated to be about 30 to 40 tons per year with a global capacity estimate of 80 tons per year. According to industry estimates, global production totaled 40 tons. Scandium was recovered from cobalt, nickel, titanium, and zirconium process streams. China was the leading producer. Prices quoted for scandium oxide in the United States generally decreased over a 5-year period.

In 2024, a metallurgical complex in southwestern Quebec, Canada, extracted scandium from waste streams and was planning to increase capacity from the current 3 tons per year to 12 tons per year; the increase in capacity was expected to be completed by 2025. The company is producing scandium oxide from waste streams of titanium dioxide production.

In Europe, the European Institute of Innovation & Technology started the ScaVanger project in France to produce scandium. Currently, there is no production of scandium in the European Union. The major European Union import sources for scandium are China (from the titanium dioxide industry and rare-earth-element production) and the Philippines, Kazakhstan, and Ukraine (from nickel-laterite tailings and uranium production waste). Beginning in 2026, the ScaVanger project is scheduled to begin commissioning 21 tons per year of scandium oxide production capacity as a byproduct of titanium dioxide pigment production.

In the United States, there is no current mine production of scandium but the polymetallic Elk Creek deposit in Nebraska contained a reserve of 2,600 tons of scandium. In 2023, a pilot-scale facility in New Freedom, PA, produced one kilogram of aluminum-scandium ingot.

In Australia, several polymetallic projects were under development and seeking permitting, financing, and offtake agreements including the Nyngan, Owendale, Sconi, and Sunrise projects.

In the Philippines, the Taganito high-pressure acid-leach nickel commercial plant recovered about 11,000 tons of scandium oxalate in 2024. Scandium oxalate was used to produce scandium oxide in Japan.

In Tangshan, Hebei Province, China, new scandium oxide production capacity reached 20 tons per year.

World Mine Production and Reserves:[6] No scandium was recovered from mining operations in the United States. As a result of its low concentration, scandium is produced exclusively as a byproduct during processing of various ores or recovered from previously processed tailings or residues. Historically, scandium was produced as byproduct material in China (iron ore, rare earths, titanium, and zirconium), Kazakhstan (uranium), the Philippines (nickel), Russia (apatite and uranium), and Ukraine (uranium). Foreign mine production data for 2023 and 2024 were not available.

World Resources:[6] Resources of scandium were abundant. Scandium's crustal abundance is greater than that of lead. Scandium lacks affinity for the common ore-forming anions; therefore, it is widely dispersed in the lithosphere and forms solid solutions with low concentrations in more than 100 minerals. Scandium resources have been identified in Australia, Canada, China, Finland, Guinea, Kazakhstan, Madagascar, Norway, the Philippines, Russia, South Africa, Ukraine, and the United States. Australia's reserves were about 37,000 tons of scandium as accessible Economic Demonstrated Resources (EDR) as of December 2023.[7]

Substitutes: Titanium and aluminum high-strength alloys as well as carbon-fiber materials may substitute in high-performance scandium-alloy applications. Under certain conditions, light-emitting diodes may displace mercury-vapor high-intensity lamps that contain scandium iodide. In some applications that rely on scandium's unique properties, substitution is not possible.

[e]Estimated. NA Not available.
[1]See also the Rare Earths chapter. Scandium is one of the 17 rare-earth elements.
[2]Source: Alfa Aesar, a part of Thermo Fisher Scientific Inc.
[3]Source: Sigma-Aldrich, a part of MilliporeSigma.
[4]Source: Stanford Advanced Materials.
[5]Defined as imports – exports. Quantitative data were not available.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 12,000 tons.

SELENIUM

(Data in metric tons, selenium content, unless otherwise specified)

Domestic Production and Use: Selenium is recovered principally as a byproduct of the electrolytic refining of primary copper, where it accumulates in the residues of copper anodes. In 2024, two primary electrolytic copper refineries operated in the United States, one in Texas and one in Utah, and produced crude selenium and selenium-bearing anode slimes. Selenium was not refined in the United States. Downstream companies processed imported selenium to manufacture high-purity selenium products, selenium dioxide, and other selenium compounds. Domestic selenium production, consumption, and stocks were withheld to avoid disclosing company proprietary data.

Selenium is used in agriculture as a fertilizer additive to increase plant tolerance to environmental stressors; in antidandruff shampoos as an active ingredient; in blasting caps to control delays; in catalysts to enhance selective oxidation; in copper, lead, and steel alloys to improve machinability; in the electrolytic production of manganese metal to increase yields; in glass manufacturing to decolorize the green tint caused by iron impurities in container glass and other soda-lime silica glass; in gun bluing to improve cosmetic appearance and provide corrosion resistance; in photocells and solar cells used in electronics for its photovoltaic and photoconductive properties; in pigments to produce a red color; in plating solutions to improve appearance and durability; in rubber-compounding chemicals to act as a vulcanizing agent; and in thin-film photovoltaic copper-indium-gallium-diselenide (CIGS) solar cells. Selenium is also an essential micronutrient and is used as a dietary supplement for humans and livestock. In 2024, estimated end uses for selenium in global consumption were metallurgy (including electrolytic manganese metal production), 40%; agriculture and animal health, 20%; glass manufacturing, 20%; electronics and photovoltaics, 10%; chemicals and pigments, 5%; and other applications, 5%.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, crude and anode slimes	W	W	W	W	W
Imports for consumption:					
Selenium	366	346	351	269	230
Selenium dioxide	18	71	10	8	5
Exports[1]	147	227	192	94	60
Consumption, apparent[2]	W	W	W	W	W
Price, annual average, dollars per kilogram:					
United States[3]	14.58	18.18	23.07	23.11	24
Europe[4]	14.71	18.47	19.82	19.30	24
Stocks, producer, yearend	W	W	W	W	W
Net import reliance[5] as a percentage of apparent consumption	>75	>50	>50	>50	>50

Recycling: Domestic production of secondary selenium was estimated to be very small because most scrap from older photocopiers and electronic materials was exported for recovery of the contained selenium.

Import Sources (2020–23): Selenium: Philippines, 24%; Mexico, 15%; Canada, 10%; Poland, 10%; and other, 41%. Selenium dioxide: Republic of Korea, 82%; China, 7%; Philippines, 7%; Germany, 4%; and other, <1%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Selenium	2804.90.0000	Free.
Selenium dioxide	2811.29.2000	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The supply of selenium is directly affected by the supply of materials from which it is a byproduct, primarily copper. In 2024, domestic production of crude selenium and selenium-bearing copper anode slimes was estimated to have increased from that in 2023, reflecting greater output of copper cathode from electrolytic refineries in the United States. The annual average price for selenium in U.S. warehouses was an estimated $24 per kilogram in 2024 compared with $23.11 per kilogram in 2023. In Europe, limited availability of selenium, steady demand, and higher costs of purchasing selenium from China increased the annual average price to an estimated $24 per kilogram in 2024 from $19.30 per kilogram in 2023.

China was the leading producer of refined selenium in 2024 and accounted for nearly 50% of estimated global output (excluding production in multiple countries for which available information was inadequate to make reliable estimates of output). Production in China increased significantly over the past 10 years, corresponding with an increase of about

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SELENIUM

60% in the production capacity of electrolytically refined copper. The production capacity of copper anode, the feedstock material for electrolytic copper refineries, nearly doubled over the same time period. Selenium demand in China for electrolytic manganese production and glass manufacturing has decreased in recent years, whereas demand for use in agriculture and animal health, electronics, and solar cells has increased. In 2024, output of refined selenium in Sweden was estimated to be zero because of a fire in June 2023 that prevented operations at the Ronnskar refinery. Production in Serbia was estimated to increase significantly in 2024 owing to a recently completed expansion at the Bor refinery.

World Refinery Production and Reserves: The values shown for reserves reflect the estimated selenium content of copper reserves except for those of China, which represent reported reserves of selenium. Reserves for Canada, Peru, and the United States were revised based on company and Government reports.

	Refinery production[e, 6]		Reserves[7]
	2023	2024	
United States (crude and anode slimes)	W	W	10,000
Belgium	200	200	—
Canada	130	130	6,500
China	[8]1,780	1,800	5,000
Finland	[8]122	170	300
Germany	50	50	—
India	14	14	500
Japan	680	710	—
Peru	[8]50	50	16,000
Poland	[8]74	74	3,000
Russia	350	340	26,000
Serbia	24	60	NA
South Africa	9	9	NA
Sweden	4	—	500
Turkey	50	50	NA
Uzbekistan	2	2	NA
Other countries[9]	NA	NA	24,000
World total (rounded)	[10]3,530	[10]3,700	92,000

World Resources:[7] Reserves for selenium are based on identified copper deposits and average selenium content. Other potential sources of selenium include lead, nickel, and zinc ores. Coal generally contains significant quantities of selenium, but recovery of selenium from coal fly ash, although technically feasible, does not appear likely to be economical in the foreseeable future.

Substitutes: Amorphous silicon and cadmium telluride are the two principal competitors with CIGS in thin-film photovoltaic solar cells. Organic pigments have been developed as substitutes for cadmium sulfoselenide pigments. Silicon is the major substitute for selenium in low- and medium-voltage rectifiers. Sulfur dioxide can be used as a replacement for selenium dioxide in the production of electrolytic manganese metal but is not as energy efficient. Other substitutes include bismuth, lead, and tellurium in free-machining alloys; bismuth and tellurium in lead-free brasses; cerium oxide as either a colorant or decolorant in glass; and tellurium in pigments and rubber.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Includes Schedule B of the United States number 2804.90.0000 (selenium) only; there is no exclusive Schedule B number for selenium dioxide.
[2]Defined as production (selenium content of crude selenium and anode slimes) + imports (excluding selenium dioxide) – exports ± adjustments for industry stock changes.
[3]Minimum purity of 99.5%, free on board, U.S. warehouse. Source: Argus Media Group, Argus Non-Ferrous Markets.
[4]Minimum purity of 99.5%, in warehouse, Rotterdam. Source: Argus Media Group, Argus Non-Ferrous Markets.
[5]Defined as imports (excluding selenium dioxide) – exports ± adjustments for industry stock changes.
[6]Unless otherwise noted, data relate to refinery output only insofar as possible. Countries that produced selenium contained in copper ore and concentrates, copper smelter products (blister and anodes), and (or) refinery residues but did not recover refined selenium from these materials are excluded.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]Reported.
[9]In addition to the countries listed, Australia, Chile, Iran, Kazakhstan, the Republic of Korea, Mexico, the Philippines, and Zimbabwe may have produced refined selenium, but available information was inadequate to make reliable estimates of output.
[10]Excludes U.S. production.

SILICON

(Data in thousand metric tons, silicon content, unless otherwise specified)

Domestic Production and Use: Ferrosilicon and silicon metal were produced at five facilities in 2024, all east of the Mississippi River. An additional silicon metal facility was idled at the end of 2023 owing to poor market conditions. Most ferrosilicon was consumed in the ferrous foundry and steel industries, predominantly in the Eastern United States, and was sourced primarily from domestic quartzite (silica). The main consumers of silicon metal were producers of aluminum alloys and the chemical industry, in particular for the manufacture of silicones. Silicon metal may be further processed into ultra-high-purity semiconductor- or solar-grades, commonly referred to as polysilicon. Four companies produced polysilicon in the United States.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, ferrosilicon[1] and silicon metal[2]	W	W	W	W	W
Imports for consumption:					
Ferrosilicon, all grades	140	125	175	153	150
Silicon metal	97	97	116	79	110
Exports:					
Ferrosilicon, all grades	4	7	9	5	4
Silicon metal	32	53	47	42	40
Consumption, apparent,[3] ferrosilicon[1] and silicon metal[2]	W	W	W	W	W
Price, average, cents per pound of silicon:					
Ferrosilicon, 50% silicon[4]	103.38	137.94	NA	NA	NA
Ferrosilicon, 75% silicon[5]	87.40	192.28	312.10	142.23	130
Silicon metal[2, 5]	96.84	220.31	361.86	179.69	180
Stocks, producer, ferrosilicon[1] and silicon metal,[2] yearend	W	11	17	15	14
Net import reliance[6] as a percentage of apparent consumption:					
Ferrosilicon, all grades	>50	<50	>50	>50	>50
Silicon metal[2]	<50	<25	<50	<50	<50
Total	<50	<50	<50	<50	<50

Recycling: Insignificant.

Import Sources (2020–23): Ferrosilicon: Russia, 37%; Brazil, 14%; Canada, 13%; Malaysia, 9%; and other, 27%. Silicon metal: Brazil, 38%; Canada, 28%; Norway, 13%; Australia, 5%; and other, 16%. Total: Brazil, 24%; Russia, 23%; Canada, 19%; Malaysia, 7%; and other, 27%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Silicon:		
More than or equal to 99.99% silicon	2804.61.0000	Free.
More than or equal to 99.00% but less than 99.99% silicon	2804.69.1000	5.3% ad valorem.
Other	2804.69.5000	5.5% ad valorem.
Ferrosilicon:		
More than 55% but less than or equal to 80% silicon:		
More than 3% calcium	7202.21.1000	1.1% ad valorem.
Other	7202.21.5000	1.5% ad valorem.
More than 80% but less than or equal to 90% silicon	7202.21.7500	1.9% ad valorem.
More than 90% silicon	7202.21.9000	5.8% ad valorem.
Other:		
More than 2% magnesium	7202.29.0010	Free.
Other	7202.29.0050	Free.

Depletion Allowance: Quartzite, 14% (domestic and foreign); gravel, 5% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Combined domestic ferrosilicon and silicon metal production in 2024 was withheld to avoid disclosing proprietary information but was estimated to be less than that in 2023. The January through September 2024 average U.S. spot price for 75%-grade ferrosilicon was almost 9% less than the annual average price in 2023, and the average U.S. spot price of silicon metal was 180.00 cents per pound compared with the annual average of 179.69 cents per pound in 2023.

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SILICON

Since the CHIPS and Science Act was signed into law in 2022, the U.S. Department of Commerce announced as of October 2024 preliminary agreements with 20 companies for 32 semiconductor manufacturing projects in 20 States. In total, these projects have received almost $34 billion of the available $39 billion in direct funding and almost $29 billion in loans. The Department of Commerce planned to allocate the remaining funds to CHIPS and Science Act grantees by the end of 2024.

As part of a new integrated silicon-based solar supply chain facility in Georgia, production of silicon solar modules began in April 2024. The facility was expected to be fully operational in 2025 and will manufacture silicon ingots, wafers, cells, and modules. In Washington, a solar-grade polysilicon production facility was restarted after being idle since 2019. Shipment of the polysilicon was pending following third party quality testing. In Montana, a facility stopped production of its electronic-grade polysilicon to focus on silicon gas production.

Excluding the United States, ferrosilicon accounted for more than 50% of world silicon production on a silicon-content basis in 2024. China accounted almost 80% of total global estimated production of silicon materials in 2024. Global production of silicon materials, on a silicon-content basis, was estimated to have increased slightly from that in 2023. In 2024, Canada's Minister of Energy and Natural Resources added silicon metal to its critical minerals list and silicon metal was included as a strategic raw material in the European Union's Critical Raw Materials Act owing to its importance in the manufacture of semiconductor chips, the electronics market, and solar power generation.

World Production:

	Ferrosilicon[e]		Silicon metal[e]	
	2023	2024	2023	2024
United States	W	W	W	W
Australia	—	—	39	40
Bhutan	82	80	—	—
Brazil	190	200	196	190
Canada	23	20	29	30
China	3,640	3,500	3,630	3,900
France	23	20	90	90
Germany	—	—	59	60
Iceland	73	70	24	20
India	59	60	—	—
Kazakhstan	127	130	7	7
Malaysia	91	130	—	—
Norway	176	180	123	120
Poland	33	30	—	—
Russia	473	470	54	50
South Africa	37	40	13	10
Spain	44	40	5	5
Other countries	119	130	11	78
World total (rounded)[7]	5,190	5,100	4,280	4,600

World Resources:[8] World and domestic resources for making silicon metal and alloys are abundant and, in most producing countries, adequate to supply world requirements for many decades. The source of the silicon is silica in various natural forms, such as quartzite.

Substitutes: Aluminum, silicon carbide, and silicomanganese can be substituted for ferrosilicon in some applications. Gallium arsenide and germanium are the principal substitutes for silicon in semiconductor and infrared applications.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Ferrosilicon grades include the two standard grades of ferrosilicon—50% silicon and 75% silicon—plus miscellaneous silicon alloys.
[2]Metallurgical-grade silicon metal.
[3]Defined as production + imports – exports ± adjustments for industry stock changes.
[4]Source: CRU Group, transaction prices based on weekly averages. Average spot prices for ferrosilicon, 50% grade, were discontinued in April 2022.
[5]Source: S&P Global Platts Metals Week, mean import prices based on monthly averages. Estimated 2024 price is the mean based on monthly average of January through September 2024.
[6]Defined as imports – exports ± adjustments for industry stock changes.
[7]Excludes U.S. production.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.

SILVER

(Data in metric tons,[1] silver content, unless otherwise specified)

Domestic Production and Use: In 2024, U.S. mines produced approximately 1,100 tons of silver with an estimated value of $960 million. Silver was produced at 4 silver mines and as a byproduct or coproduct from 31 domestic base- and precious-metal operations. Silver was produced in 12 States, and Alaska continued as the country's leading silver-producing State, followed by Idaho. There were 24 U.S. refiners that reported production of commercial-grade silver with an estimated total output of 2,400 tons from domestic and foreign ores and concentrates and from new and old scrap. The physical properties of silver include high ductility, electrical conductivity, malleability, and reflectivity. In 2024, the estimated domestic uses for silver were physical investment (bars), 30%; electrical and electronics, 29%; coins and medals, 12%; photovoltaics (PV), 12%; jewelry and silverware, 6%; brazing and solder, 4%; and other industrial uses and photography, 7%. Other applications for silver include use in antimicrobial bandages, clothing, pharmaceuticals, and plastics; batteries; bearings; brazing and soldering; catalytic converters in automobiles; electroplating; inks; mirrors; photography; photovoltaic solar cells; water purification; wood treatment; and processing of spent ethylene oxide catalysts. Mercury and silver, the main components of dental amalgam, are biocides, and their use in amalgam inhibits recurrent decay.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Mine	1,080	1,020	1,010	1,020	1,100
Refinery:					
Primary	1,360	1,920	1,850	1,140	1,200
Secondary (new and old scrap)	582	908	1,090	1,150	1,200
Imports for consumption[2]	6,730	6,160	4,490	4,950	4,200
Exports[2]	141	137	276	73	140
Consumption, apparent[3]	8,250	7,950	6,320	7,070	6,400
Price, bullion, average, dollars per troy ounce[4]	20.58	25.23	21.88	23.54	27.70
Stocks, yearend:					
Industry	55	56	55	27	35
Treasury[5]	498	498	498	498	498
New York Commodities Exchange—COMEX	12,334	11,064	9,299	8,643	9,520
Employment, mine and mill, number[6]	1,175	1,440	1,396	1,455	1,400
Net import reliance[7] as a percentage of apparent consumption	80	76	67	69	64

Recycling: In 2024, approximately 1,200 tons of silver was recovered from new and old scrap, accounting for about 19% of apparent consumption.

Import Sources (2020–23):[2] Mexico, 44%; Canada, 17%; Republic of Korea, 5%; Poland, 5%; and other, 29%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Silver ores and concentrates	2616.10.0040	0.8 ¢/kg on lead content.
Bullion	7106.91.1010	Free.
Dore	7106.91.1020	Free.

Depletion Allowance: 15% (domestic), 14% (foreign).

Government Stockpile: The U.S. Department of the Treasury maintains stocks of silver (see salient statistics above).

Events, Trends, and Issues: The estimated average silver price in 2024 was $27.70 per troy ounce, 18% higher than the average price in 2023. The price began the year at $24.00 per troy ounce and decreased to the low of $22.00 per troy ounce on January 22. During the first 10 months of 2024, the price reached a high of $34.60 per troy ounce on October 22.

In 2024, global consumption of silver was an estimated 37,000 tons, a slight increase from that in 2023. Coin and bar consumption decreased by 13% in 2024, but consumption of silver for industrial uses was estimated to have increased by 9% compared with that in 2023 owing to growth in the global economy, which was expected to increase demand for consumer electronics, and rising electric vehicle output. Consumption of silver in jewelry and silverware was estimated to have increased by 4% and 7%, respectively. Global consumption of silver exceeded supply and was cited as a reason for price increases in 2024.[8]

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SILVER

World silver mine production decreased in 2024 to an estimated 25,000 tons compared with 25,500 tons in 2023. Domestic silver mine production was estimated to have increased by 6% in 2024. The Rochester Mine in Nevada was ramping up an expansion project and the Lucky Friday Mine in Idaho resumed production in January 2024 after a fire in August 2023.

World Mine Production and Reserves: Reserves for China, Peru, and Poland were revised based on Government reports.

	Mine production		Reserves[9]
	2023	2024[e]	
United States	1,020	1,100	23,000
Argentina	808	800	6,500
Australia	1,030	1,000	[10]94,000
Bolivia	1,350	1,300	22,000
Canada	306	300	4,900
Chile	1,260	1,200	26,000
China	3,400	3,300	70,000
India	813	800	8,000
Kazakhstan	985	1,000	NA
Mexico	6,290	6,300	37,000
Peru	3,200	3,100	140,000
Poland	1,320	1,300	61,000
Russia	1,240	1,200	92,000
Sweden	404	400	NA
Other countries	2,050	2,100	57,000
World total (rounded)	25,500	25,000	640,000

World Resources:[9] Although silver was a principal product at several mines, silver was primarily obtained as a byproduct from lead-zinc, copper, and gold mines, in descending order of silver production. The polymetallic ore deposits from which silver was recovered account for more than two-thirds of U.S. and world resources of silver. Most recent silver discoveries have been associated with gold occurrences; however, copper and lead-zinc occurrences that contain byproduct silver will continue to account for a significant share of reserves and resources in the future.

Substitutes: Digital imaging, film with reduced silver content, silverless black-and-white film, and xerography substitute for traditional photographic applications for silver. Surgical pins and plates may be made with stainless steel, tantalum, and titanium in place of silver. Stainless steel may be substituted for silver flatware. Nonsilver batteries may replace silver batteries in some applications. Aluminum and rhodium may be used to replace silver that was traditionally used in mirrors and other reflecting surfaces. Silver may be used to replace more costly metals in catalytic converters for off-road vehicles.

[e]Estimated. NA Not available.

[1]One metric ton (1,000 kilograms) = 32,150.7 troy ounces.

[2]Silver content of base metal ores and concentrates, ash and residues, refined bullion, and dore; excludes coinage and waste and scrap material.

[3]Defined as mine production + secondary production + imports – exports ± adjustments for Government and industry stock changes.

[4]Engelhard's industrial bullion quotations. Source: S&P Global Platts Metals Week.

[5]Source: U.S. Mint. Balance in U.S. Mint only; includes deep storage and working stocks.

[6]Source: U.S. Department of Labor, Mine Safety and Health Administration (MSHA). Only includes mines where silver is the primary product.

[7]Defined as imports – exports ± adjustments for Government and industry stock changes.

[8]Source: Metals Focus, 2024, World silver survey 2024: Silver Institute, prepared by Metals Focus, 88 p. (Accessed October 10, 2024, at https://www.silverinstitute.org/wp-content/uploads/2024/04/World-Silver-Survey-2024.pdf.)

[9]See Appendix C for resource and reserve definitions and information concerning data sources.

[10]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 27,000 tons.

SODA ASH

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: The total value of domestic soda ash (sodium carbonate) produced in 2024 was an estimated $2.5 billion[1] and the quantity produced was an estimated 12 million tons, 10% more than that in 2023. The U.S. soda ash industry consisted of four companies in Wyoming operating five plants and one company in California operating one plant. The five producing companies have a combined nameplate capacity of 13.9 million tons per year (15.3 million short tons per year). Borax, salt, and sodium sulfate were produced as coproducts of sodium carbonate production in California. Chemical caustic soda, sodium bicarbonate, and sodium sulfite were manufactured as coproducts at several of the Wyoming soda ash plants. Sodium bicarbonate was produced at an operation in Colorado using soda ash feedstock shipped from the company's Wyoming facility.

Based on 2024 quarterly reports, the estimated distribution of soda ash by end use was glass, 45%; chemicals, 29%; miscellaneous uses, 9%; distributors, 7%; soap and detergents, 5%; flue gas desulfurization, 3%; pulp and paper, 1%; and water treatment, 1%.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production[2]	9,990	11,300	11,300	10,900	12,000
Imports for consumption	98	130	61	45	10
Exports	5,590	6,840	6,470	6,650	7,400
Consumption:					
Apparent[3]	4,490	4,570	4,760	4,380	4,600
Reported	4,440	4,640	4,640	4,460	4,200
Price, average unit value of sales (natural source), free on board (f.o.b.) mine or plant:					
Dollars per metric ton	140.70	133.37	178.52	211.48	220
Dollars per short ton	127.64	120.99	161.95	191.85	200
Stocks, producer, yearend	305	278	364	251	300
Employment, mine and plant, number[e]	2,400	2,400	2,400	2,400	2,400
Net import reliance[4] as a percentage of apparent consumption	E	E	E	E	E

Recycling: No soda ash was recycled by producers; however, glass container producers use cullet glass, thereby reducing soda ash consumption.

Import Sources (2020–23): Turkey, 92%; and other, 8%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Disodium carbonate	2836.20.0000	1.2% ad valorem.

Depletion Allowance: Natural, 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic production of soda ash in 2024 was estimated to have increased by 10% compared with that in 2023, and estimated exports increased by 11%. Reported consumption decreased by 6%, and apparent consumption decreased by 3% compared with that in 2023. More than one-half of U.S. soda ash production was exported in 2024.

Relatively low production costs and lower environmental impacts provided natural soda ash producers in Turkey and the United States some advantage over producers of synthetic soda ash. The production of synthetic soda ash normally consumes more energy and releases more carbon dioxide than that of natural soda ash.

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SODA ASH

In 2024, China produced an estimated 36 million tons of soda ash (most of which was synthetic) and was the leading global producer followed by, in descending order, the United States and Turkey. Together, China, Turkey, and the United States accounted for 81% of global soda ash production in 2024.

In mid-2023, China expanded its production capacity for natural soda ash by approximately 5 million tons per year with the opening of a new mining and production facility. These new operations contributed to a 10% increase in China's production in 2024 compared with production in 2023.

World Mine Production and Reserves:

	Mine production		Reserves[5, 6]
	2023	2024[e]	
Natural:			
United States	10,900	12,000	[7]23,000,000
Botswana	262	270	16,000
Ethiopia	[e]18	20	400,000
Kenya	[e]300	300	7,000
Turkey[8]	[e]11,500	11,000	840,000
Other countries[9]	NA	NA	280,000
World total, natural (rounded)	23,000	24,000	25,000,000
World total, synthetic	45,900	49,000	XX
World total, natural and synthetic (rounded)	68,800	73,000	XX

World Resources:[6] Natural soda ash is obtained from trona and sodium carbonate-rich brines. The world's largest deposit of trona is in the Green River Basin of Wyoming. About 47 billion tons of identified soda ash resources could be recovered from the 56 billion tons of bedded trona and the 47 billion tons of interbedded or intermixed trona and halite, which are in beds more than 1.2 meters thick. Underground room-and-pillar mining, using conventional and continuous mining, is the primary method of mining Wyoming trona ore. This method has an average 45% mining recovery, whereas average recovery from solution mining is 30%. Improved solution-mining techniques, such as horizontal drilling to establish communication between well pairs, could increase this extraction rate and enable companies to develop some of the deeper trona beds. Wyoming trona resources are being depleted at the rate of about 15 million tons per year (8.3 million tons of soda ash). Searles Lake and Owens Lake in California contain an estimated 810 million tons of soda ash reserves. At least 95 natural sodium carbonate deposits have been identified in the world, the resources of only some of which have been quantified. Although soda ash can be manufactured from salt and limestone, both of which are practically inexhaustible, synthetic soda ash is costlier to produce and generates environmental wastes.

Substitutes: Caustic soda can be substituted for soda ash in certain uses, particularly in the pulp and paper, water treatment, and certain chemical sectors. Soda ash, soda liquors, or trona can be used as feedstock to manufacture chemical caustic soda, which is an alternative to electrolytic caustic soda.

[e]Estimated. E Net exporter. NA Not available. XX Not applicable.
[1]Does not include values for soda liquors and mine waters.
[2]Natural only.
[3]Defined as production + imports – exports ± adjustments for industry stock changes.
[4]Defined as imports – exports ± adjustments for industry stock changes.
[5]The reported quantities are sodium carbonate only. About 1.8 tons of trona yield 1 ton of sodium carbonate.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]From trona, nahcolite, and dawsonite deposits, in order of abundance and commercial significance.
[8]Turkey is estimated to produce synthetic soda ash; however, because the majority of soda ash production is from natural trona, Turkey's production is included in "World total, natural."
[9]China is estimated to produce natural trona; however, because the majority of soda ash production is synthetic, China's production is included in "World total, synthetic."

STONE (CRUSHED)[1]

(Data in million metric tons unless otherwise specified)

Domestic Production and Use: In 2024, an estimated 1.5 billion tons of crushed stone valued at $26 billion was produced by an estimated 1,400 companies operating 3,500 quarries and more than 180 sales and (or) distribution yards in 50 States. Leading States were, in descending order of production, Texas, Florida, Pennsylvania, Missouri, Ohio, North Carolina, Georgia, Tennessee, Indiana, and Virginia, which together accounted for about 55% of total crushed stone output. Of the total domestic crushed stone produced in 2024, about 70% was limestone and dolomite; 14%, granite; 6%, traprock; 6%, miscellaneous stone; and 3%, sandstone and quartzite; the remaining 1% was divided, in descending order of tonnage, among marble, volcanic cinder and scoria, calcareous marl, shell, and slate. An estimated 72% of crushed stone was used as a construction aggregate, mostly for road construction and maintenance; 17% for cement manufacturing; 6% for lime manufacturing; 1% for agricultural uses; and the remaining 4% for other chemical, special, and miscellaneous uses and products.

The output of crushed stone in the United States shipped for consumption in the first 9 months of 2024 was 1.11 billion tons, a decrease of 5% compared with that in the same period in 2023. Third-quarter shipments for consumption decreased by 6% compared with those in the same period in 2023. Additional production information, by quarter, for each State, geographic division, and the United States is reported by the U.S. Geological Survey in its quarterly Mineral Industry Surveys for construction sand and gravel and crushed stone.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Sold or used by producers	1,460	1,510	1,540	1,550	1,500
Recycled material	31	33	33	37	37
Imports for consumption	20	19	16	14	14
Exports	([2])	([2])	([2])	([2])	([2])
Consumption, apparent[3]	1,510	1,560	1,590	1,610	1,500
Price, average unit value, dollars per metric ton	12.69	13.26	14.31	15.86	17.50
Employment, quarry and mill, number[4]	68,000	68,900	70,400	71,300	71,600
Net import reliance[5] as a percentage of apparent consumption	1	1	1	1	1

Recycling: Road surfaces made of asphalt concrete and portland cement concrete surface layers, which contain crushed stone aggregate, were recycled on a limited but increasing basis in most States. In 2024, asphalt and portland cement concrete road surfaces were recycled in all 50 States.

Import Sources (2020–23): Canada, 37%; Mexico, 34%; The Bahamas, 14%; Honduras, 12%; and other, 3%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Chalk:		
Crude	2509.00.1000	Free.
Other	2509.00.2000	Free.
Limestone, except pebbles and gravel	2517.10.0020	Free.
Crushed or broken stone	2517.10.0055	Free.
Marble granules, chippings and powder	2517.41.0000	Free.
Stone granules, chippings and powders	2517.49.0000	Free.
Limestone flux; limestone and other calcareous stone	2521.00.0000	Free.

Depletion Allowance: For some special uses, 14% (domestic and foreign); if used as ballast, concrete aggregate, riprap, road material, and similar purposes, 5% (domestic and foreign).

Government Stockpile: None.

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STONE (CRUSHED)

<u>Events, Trends, and Issues</u>: U.S. crushed stone production was about 1.5 billion tons in 2024, a decrease of 6% compared with 1.55 billion tons in 2023. Apparent consumption decreased to 1.5 billion tons. Consumption of crushed stone decreased in 2024 because of significant weather events and continued decreases in residential housing demand caused by interest rates continuing to be at some of the highest levels in 23 years. Usually, commercial and heavy-industrial construction activity, infrastructure funding, labor availability, new single-family housing unit starts, and weather affect rates of crushed stone production and consumption. Long-term increases in construction aggregates demand are influenced by activity in the public and private construction sectors, as well as by construction work related to infrastructure improvements around the Nation.

The 2021 Infrastructure Investment and Jobs Act reauthorized surface transportation programs for 5 years and authorized investment of additional funding to repair roads and bridges and support major, transformational projects. The 2021 law authorized $1.2 trillion in funding and will expire at the end of the 2026 Federal fiscal year. The funding included $118 billion to the Highway Trust Fund—$90 billion to the highway account and $28 billion to the transit account. During the first 9 months of 2024, total highway construction spending was 8% more than that in the same period in 2023.

The underlying factors that would support an increase in prices for crushed stone are expected to be present in 2025, especially in and near metropolitan areas. Shortages in some urban and industrialized areas are expected to continue to increase owing to local zoning regulations and land-development alternatives. These issues are expected to continue and to cause new crushed stone quarries to be located away from large population centers. Resultant regional shortages of crushed stone and higher fuel costs could result in higher-than-average price increases in industrialized and urban areas.

The crushed stone industry continued to address health and safety regulations, permitting and zoning issues, and environmental restrictions in 2024.

<u>World Mine Production and Reserves</u>:

	Mine production 2023	Mine production 2024[e]	Reserves[6]
United States	1,550	1,500	Adequate, except where special types are needed or where local shortages exist.
Other countries[7]	NA	NA	
World total	NA	NA	

<u>World Resources</u>:[6] Stone resources are plentiful throughout the world. The supply of high-purity limestone and dolomite suitable for specialty uses is limited in many geographic areas. The largest resources of high-purity limestone and dolomite in the United States are in the central and eastern parts of the country.

<u>Substitutes</u>: Crushed stone substitutes for roadbuilding include sand and gravel, and iron and steel slag. Substitutes for crushed stone used as construction aggregates include construction sand and gravel, iron and steel slag, sintered or expanded clay or shale, perlite, or vermiculite. Increasingly, recycled asphalt and portland cement concretes are being substituted for virgin aggregate, although the percentage of total aggregate supplied by recycled materials remained very small in 2024.

[e]Estimated. NA Not available.
[1]See also the Sand and Gravel (Construction) and the Stone (Dimension) chapters.
[2]Less than ½ unit.
[3]Defined as sold or used by producers + recycled material + imports – exports.
[4]Including office staff. Source: Mine Safety and Health Administration.
[5]Defined as imports – exports.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]No reliable production information is available for most countries owing to the wide variety of ways in which countries report their crushed stone production. Some countries do not report production for this mineral commodity. Production information for some countries is available in the U.S. Geological Survey Minerals Yearbook, volume III, Area Reports—International.

STONE (DIMENSION)[1]

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: Approximately 2.2 million tons of dimension stone, valued at $370 million, was sold or used by U.S. producers in 2024. Dimension stone was produced by 171 companies operating 216 quarries in 33 States. The leading producing States were, in descending order by tonnage, Texas, Wisconsin, Vermont, Indiana, and Georgia. These five States accounted for 73% of the production quantity and contributed 63% of the domestic dimension stone value.

Approximately 50%, by tonnage, of dimension stone sold or used was limestone, followed by granite (19%) and sandstone (14%); the remaining 17% was divided, in descending order of tonnage, among slate, dolomite, miscellaneous stone, marble, quartzite, and traprock. By value, the leading sales or uses were for limestone (47%), granite (23%), sandstone (10%), and marble and dolomite (5% each); the remaining 10% was divided, in descending order of total value, among quartzite, slate, miscellaneous stone, and traprock.

Rough stone represented 60% of the tonnage and 54% of the value of all the dimension stone sold or used by domestic producers, including exports. The leading uses and distribution of rough stone, by tonnage, were in building and construction (60%) and as irregular-shaped stone (27%). The leading uses and distribution of dressed stone, by tonnage, were in ashlars and partially squared pieces (50%); flagging and slabs and blocks for building and construction (9% each); and roofing slate (7%).

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Sold or used by producers:[2]					
Quantity	2,120	2,290	2,380	[e]2,300	2,200
Value, million dollars	397	413	421	[e]410	370
Imports for consumption, value, million dollars	1,750	2,200	2,312	1,950	1,900
Exports, value, million dollars	48	50	54	55	58
Consumption, apparent, value, million dollars[3]	2,100	2,560	2,680	[e]2,300	2,200
Price	Variable, depending on type of product				
Employment, quarry and mill, number[4]	3,800	3,700	3,800	3,700	3,700
Net import reliance[5] as a percentage of apparent consumption (based on value)	81	84	84	82	83
Granite only:					
Quantity, sold or used by producers	436	445	491	[e]470	450
Value, sold or used by producers, million dollars	105	108	102	[e]94	86
Imports, value, million dollars	859	901	902	748	700
Exports, value, million dollars	13	12	13	14	14
Consumption, apparent, value, million dollars[3]	951	997	991	828	770
Price	Variable, depending on type of product				
Employment, quarry and mill, number[4]	800	800	800	800	700
Net import reliance[5] as a percentage of apparent consumption (based on value)	89	89	90	89	89

Recycling: Small amounts of dimension stone were recycled, principally by restorers of old stonework.

Import Sources (2020–23, by value): All dimension stone: Brazil, 21%; China,[6] 18%; Italy, 17%; Turkey, 14%; and other, 30%. Granite only: Brazil, 41%; India, 25%; China,[6] 17%; Italy, 6%; and other, 11%.

Tariff: Dimension stone tariffs ranged from free to 6.5% ad valorem, according to type, degree of preparation, shape, and size, for countries with normal trade relations in 2023. Most crude or roughly trimmed stone was imported at 3.7% ad valorem or less.

Depletion Allowance: All dimension stone, 14% (domestic and foreign); slate used or sold as sintered or burned lightweight aggregate, 7.5% (domestic and foreign); dimension stone used for rubble and other nonbuilding purposes, 5% (domestic and foreign).

Government Stockpile: None.

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STONE (DIMENSION)

Events, Trends, and Issues: The United States remained one of the world's leading markets for dimension stone in 2024, but sales have slowed over the past few years. In 2024, the value of domestic sales of dimension stone was estimated to have decreased by 10% compared with that in 2023. Multiple unit buildings housing starts declined by 29%; total permits issued for private housing units, by 4%; and private single unit housing starts, by 3%, over the first 10 months of 2024 compared with totals in the first 10 months of 2023. Construction spending increased by 7%, which indicated that high costs may have contributed to lower demand for construction materials.

Import values for dimension stone continued to decrease, and the import and sale of dimension granite decreased again in 2024. One of the largest dimension granite producers in the United States suspended operations midway through 2024, and many other operations slowed production this past year. The large dimension granite operation was expected to reopen midway through 2025.

The Dimension Stone Committee of the standard development organization named ASTM International has proposed a new standard that tests the physical properties of dimension and other natural building stone under freeze-thaw conditions. The testing procedures would produce additional data on the mechanical performance of different building stones that are subjected to especially cold and harsh environments.

The dimension stone industry continued to address safety and health regulations and environmental restrictions in 2024, especially those concerning crystalline silica exposure. In April 2024, the Mine Safety and Health Administration published a final rule which amended its existing standards to protect miners against exposure to respirable crystalline silica.[7] The U.S. Department of Labor also funded programs across five States to increase training and awareness of silica dust exposure and among miners working in underserved areas.

World Mine Production and Reserves:

	Mine production		Reserves[8]
	2023	2024[e]	
United States	2,300	2,200	Adequate, except for certain special types and local shortages.
Other countries	NA	NA	
World total	NA	NA	

World Resources:[8] Dimension stone resources of the world are sufficient. Resources can be limited on a local level or occasionally on a regional level by the lack of a particular kind of stone that is suitable for dimension purposes.

Substitutes: Substitutes for dimension stone include aluminum, brick, ceramic tile, concrete, glass, plastics, resin-agglomerated stone, and steel.

[e]Estimated. NA Not available.
[1]See also the Stone (Crushed) chapter.
[2]Includes granite, limestone, and other types of dimension stone.
[3]Defined as sold or used + imports – exports.
[4]Excludes office staff.
[5]Defined as imports – exports.
[6]Includes Hong Kong.
[7]Source: Mine Safety and Health Administration, 2024, Lowering miner's exposure to respirable crystalline silica and improving respiratory protection: Federal Register, v. 89, no. 76, April 18, p. 28218–28485. (Accessed November 21, 2024, at https://www.govinfo.gov/content/pkg/FR-2024-04-18/pdf/2024-06920.pdf.)
[8]See Appendix C for resource and reserve definitions and information concerning data sources.

STRONTIUM

(Data in metric tons, strontium content, unless otherwise specified)

Domestic Production and Use: Domestic apparent consumption of strontium compounds and minerals decreased by 23% in 2024 compared with that in 2023. The apparent consumption of strontium compounds increased by 22%, but apparent consumption of the strontium mineral celestite decreased by 95%. Although deposits of strontium minerals occur widely throughout the United States, none have been mined since 1959. Large-scale domestic production of strontium carbonate, the principal strontium compound, ceased in 2006. Virtually all the strontium mineral celestite consumed in the United States since 2006 is estimated to have been used as an additive in drilling fluids for oil and natural-gas wells. A few domestic companies manufactured and (or) distributed small quantities of downstream strontium chemicals from imported strontium carbonate.

Based on import data, the estimated end-use distribution in the United States for strontium, including celestite and strontium compounds, was ceramic ferrite magnets, 40%; pyrotechnics and signals, 40%; drilling fluids, 2%; and other uses, including electrolytic production of zinc, glass, master alloys, and pigments and fillers,18%.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production	—	—	—	—	—
Imports for consumption:					
Celestite[1]	1,060	106	9,160	2,060	100
Strontium compounds[2]	4,440	5,020	5,740	3,330	4,000
Exports, strontium compounds[3]	32	6	15	53	3
Consumption, apparent:[4]					
Celestite	1,060	106	9,160	2,060	100
Strontium compounds	4,410	5,010	5,720	3,270	4,000
Total	5,470	5,120	14,900	5,330	4,100
Price, average unit value of celestite imports at port of exportation, dollars per ton	90	210	143	82	390
Net import reliance[4] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2020–23): Celestite: Mexico, 100%. Strontium compounds: Germany, 49%; Mexico, 43%; China, 3%; and other, 5%. Total imports: Mexico, 65%; Germany, 30%; and other, 5%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Celestite	2530.90.8010	Free.
Strontium compounds:		
Strontium metal	2805.19.1000	3.7% ad valorem.
Strontium oxide, hydroxide, peroxide	2816.40.1000	4.2% ad valorem.
Strontium nitrate	2834.29.2000	4.2% ad valorem.
Strontium carbonate	2836.92.0000	4.2% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile: None.

Events, Trends, and Issues: Imports of celestite in 2024 decreased by 95% compared with those in 2023, likely the result of decreased use in natural-gas- and oil-well-drilling fluids and consumption of stockpiled celestite imported in prior years. The weekly average active rig count[5] decreased by 15% in the first 9 months in 2024 compared with that in the same period in 2023 and remained 39% lower than that in the same period in 2019 before the global coronavirus disease 2019 (COVID-19) pandemic in 2020. In recent years, nearly all celestite imports were from Mexico and were estimated to be used as additives in drilling fluids for oil and natural gas exploration and production. Substitution of celestite by barite may also have contributed to decreased imports because barite is preferred over celestite for drilling mud. For these applications, celestite is ground but undergoes no chemical processing. A small quantity of high-value celestite imports were reported; these were most likely mineral specimens. Celestite is the raw material from which strontium carbonate and other strontium compounds are produced.

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STRONTIUM

Imports of strontium compounds were estimated to have increased by 20% in 2024. Strontium carbonate is the most traded strontium compound and is used as the raw material from which other strontium compounds are derived. Strontium carbonate is sintered with iron oxide to produce permanent ceramic ferrite magnets. Strontium nitrate, the second most traded strontium compound, contributes a brilliant red color to fireworks and signal flares, including low-noise fireworks. Smaller quantities of these and other strontium compounds and strontium metal were consumed in several other applications, including electrolytic production of zinc, glass production, master alloys, and pigments and fillers. Various novel applications of strontium, such as its use in medical and technological applications, as well as in ultraprecise atomic optical clocks, continue to be researched. In 2024, a strontium atomic clock was recognized as the most accurate timepiece to date. Also in 2024, three of the oldest stars in the universe were identified through low amounts of strontium and barium in their spectra.

In February 2024, the U.S. Department of Defense announced results of a funding opportunity under the Defense Production Act Investments program to establish domestic manufacturing for 22 critical chemicals. A company in Louisiana and a company in Ohio were selected for the domestic production of strontium nitrate, strontium oxalate, and strontium peroxide, among other chemicals. These awards were expected to improve the domestic supply chain, modernize manufacturing capacity, and lead to new jobs.

World Mine Production and Reserves:[6]

	Mine production[e]		Reserves[7]
	2023	2024	
United States	—	—	NA
Argentina	700	700	NA
China	80,000	80,000	12,000,000
Iran	200,000	200,000	7,100,000
Mexico	[8]28,000	25,000	NA
Spain	200,000	200,000	NA
World total (rounded)	509,000	510,000	Large

World Resources:[7] World resources of strontium may exceed 1 billion tons.

Substitutes: Barium can be substituted for strontium in ceramic ferrite magnets; however, the resulting barium composite will have a reduced maximum operating temperature when compared with that of strontium composites. Substituting for strontium in pyrotechnics is hindered by difficulty in obtaining the desired brilliance and visibility imparted by strontium and its compounds. In drilling mud, barite is the preferred material, but celestite may substitute for some barite, especially when barite prices are high.

[e]Estimated. NA Not available. — Zero.

[1]The strontium content of celestite ore is 43.88%, which was used to convert units of gross weight celestite ore to strontium content.

[2]Strontium compounds (with their respective strontium contents) include metal (100%); oxide, hydroxide, and peroxide (70%); carbonate (59.35%); and nitrate (41.40%). These factors were used to convert gross weight of strontium compounds to strontium content.

[3]Calculated from Schedule B number 2836.92.0000 for strontium carbonate. Other strontium compounds exports are not included because these shipments likely consisted of materials misclassified as strontium compounds.

[4]Defined as imports − exports.

[5]Source: Baker Hughes Co., 2024, Rig count overview & summary count: Baker Hughes Co. (Accessed October 17, 2024, at https://rigcount.bakerhughes.com/na-rig-count.)

[6]Gross weight of celestite in tons.

[7]See Appendix C for resource and reserve definitions and information concerning data sources.

[8]Reported.

SULFUR

(Data in thousand metric tons, sulfur content, unless otherwise specified)

Domestic Production and Use: In 2024, recovered elemental sulfur and byproduct sulfuric acid were produced at 86 operations in 26 States. Total shipments were valued at about $410 million. Elemental sulfur production was estimated to be 8.2 million tons; Louisiana and Texas accounted for about 52% of domestic production. Elemental sulfur was recovered, in descending order of tonnage, at petroleum refineries, natural-gas-processing plants, and coking plants by 31 companies at 81 plants in 25 States. Byproduct sulfuric acid, representing about 8% of production of sulfur in all forms, was recovered at five nonferrous-metal smelters in four States by four companies. Domestic elemental sulfur accounted for 65% of domestic consumption, and byproduct sulfuric acid accounted for about 7%. The remaining 28% of sulfur consumed was provided by imported sulfur and sulfuric acid. About 90% of sulfur consumed was in the form of sulfuric acid.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Recovered elemental	7,310	7,470	8,010	8,010	7,500
Other forms	579	600	636	640	660
Total (rounded)	7,880	8,070	8,640	8,650	8,200
Shipments, all forms	7,900	8,080	8,640	8,660	8,200
Imports for consumption:					
Recovered elemental[e]	2,230	2,370	1,670	1,460	1,300
Sulfuric acid	1,190	1,070	1,060	1,080	1,200
Exports:					
Recovered elemental	1,330	1,900	1,740	1,920	1,800
Sulfuric acid	64	129	123	64	50
Consumption, apparent, all forms[1]	9,940	9,490	9,490	9,220	8,800
Price, average unit value, free on board, mine and (or) plant, dollars per metric ton of elemental sulfur	24.90	90.40	177.8	58.90	50.00
Stocks, producer, yearend	109	113	126	122	110
Employment, mine and (or) plant, number	2,400	2,400	2,400	2,400	2,400
Net import reliance[2] as a percentage of apparent consumption	21	15	9	6	7

Recycling: Typically, between 2.5 million and 5 million tons of spent sulfuric acid is reclaimed from petroleum refining and chemical processes during any given year.

Import Sources (2020–23): Elemental: Canada, 79%; Kazakhstan, 8%; Russia, 8%; and other, 5%. Sulfuric acid: Canada, 55%; Mexico, 21%; Spain, 8%; and other, 16%. Total sulfur imports: Canada, 70%; Mexico, 8%; Kazakhstan, 5%; Russia, 5%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Sulfur, crude or unrefined	2503.00.0010	Free.
Sulfur, all kinds, other	2503.00.0090	Free.
Sulfur, sublimed or precipitated	2802.00.0000	Free.
Sulfuric acid	2807.00.0000	Free.

Depletion Allowance: 22% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Total U.S. sulfur production and shipments in 2024 were each estimated to be 5% less than that in 2023. Domestic production of elemental sulfur from petroleum refineries and recovery from natural gas operations was estimated to have decreased by 6%. Domestically, refinery sulfur production was expected to remain about the same as refining utilization remains high. Domestic byproduct sulfuric acid was expected to remain relatively constant, unless one or more of the remaining nonferrous-metal smelters close.

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SULFUR

Domestic phosphate rock consumption in 2024 was estimated to be about the same as that in 2023, which indicated there was no significant change in the amount of sulfur needed to process the phosphate rock into phosphate fertilizers. New sulfur demand associated with phosphate fertilizer projects was expected mostly in Africa and west Asia.

World sulfur production in 2024 was an estimated 85 million tons compared with 85.8 million tons in 2023. Starting in 2025, sulfur production from the Middle East was expected to increase owing to upgrades and new refining projects. Also, an increase in nickel production from high-pressure acid leach projects to produce battery materials was expected to increase sulfur demand.

Contract sulfur prices in Tampa, FL, began 2024 at $69 per long ton. The sulfur price increased to $81 per long ton in early March, then decreased to $76 per long ton in early July, and fourth quarter 2024 prices increased to $116 per long ton. In the past few years, sulfur prices have been variable, a result of volatility in the demand for sulfur.

World Production and Reserves:

	Production, all forms	
	2023	2024[e]
United States	8,650	8,200
Australia	900	900
Canada	4,980	5,000
Chile	1,300	1,300
China[4]	19,400	19,000
India	3,680	3,700
Iran	2,000	2,000
Japan	3,070	3,100
Kazakhstan	5,090	5,100
Korea, Republic of	3,080	3,100
Kuwait	1,300	1,300
Poland	1,040	1,100
Qatar	3,100	3,100
Russia	7,530	7,500
Saudi Arabia	7,500	7,500
Turkmenistan	870	900
United Arab Emirates	6,000	6,000
Other countries	6,270	6,400
World total (rounded)	85,800	85,000

Reserves[3]

Reserves of sulfur in crude oil, natural gas, and sulfide ores are large. Because most sulfur production is a result of the processing of fossil fuels, supplies are expected to be adequate for the foreseeable future. Because petroleum and sulfide ores can be processed long distances from where they are produced, sulfur production may not be in the country to which the reserves were attributed. For instance, sulfur from Saudi Arabian oil may be recovered at refineries in the United States.

World Resources:[3] Resources of elemental sulfur in evaporite and volcanic deposits, and sulfur associated with natural gas, petroleum, tar sands, and metal sulfides, total about 5 billion tons. The sulfur in gypsum and anhydrite is almost limitless, and 600 billion tons of sulfur is contained in coal, oil shale, and shale that is rich in organic matter. Production from these sources would require development of low-cost methods of extraction. The domestic sulfur resource is about one-fifth of the world total.

Substitutes: Substitutes for sulfur at present or anticipated price levels are not satisfactory; some acids, in certain applications, may be substituted for sulfuric acid, but usually at a higher cost.

[e]Estimated.

[1]Defined as shipments + imports – exports ± adjustments for industry stock changes.

[2]Defined as imports – exports ± adjustments for industry stock changes.

[3]See Appendix C for resource and reserve definitions and information concerning data sources.

[4]Sulfur production in China includes byproduct elemental sulfur recovered from natural gas and petroleum, the estimated sulfur content of byproduct sulfuric acid from metallurgy, and the sulfur content of sulfuric acid from pyrite.

TALC AND PYROPHYLLITE[1]

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: Three companies operated five talc-producing mines in three States during 2024, and domestic production of crude talc was estimated to have increased to 530,000 tons valued at $27 million. Talc was mined in Montana, Texas, and Vermont. Total sales of talc by U.S. producers were estimated to be 510,000 tons valued at about $170 million. Talc produced and sold in the United States was used in plastics, 32%; ceramics (including automotive catalytic converters), 21%; paint, 18%; paper, 9%; roofing, 8%; and rubber, 6%. The remaining 6% was for agriculture, cosmetics, export, insecticides, and other miscellaneous uses.

Two companies in North Carolina mined and processed pyrophyllite in 2024. Domestic production data were withheld to avoid disclosing company proprietary data and were essentially unchanged from those in 2023. Pyrophyllite was sold for ceramic, paint, and refractory products.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, mine	491	577	511	508	530
Sold by producers	461	556	548	530	510
Imports for consumption	189	278	346	235	210
Exports	196	236	203	204	200
Consumption, apparent[2]	454	598	691	561	520
Price, average, milled, dollars per metric ton[3]	265	322	298	333	330
Employment, mine and mill, number:[4]					
Talc	187	334	362	381	350
Pyrophyllite	31	32	37	38	37
Net import reliance[5] as a percentage of apparent consumption	E	7	21	6	2

Recycling: Insignificant.

Import Sources (2020–23): Pakistan, 51%; Canada, 25%; China, 12%; and other, 12%. Large quantities of crude talc were estimated to have been mined in Afghanistan before being milled in and exported from Pakistan.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Natural steatite and talc:		
Not crushed, not powdered	2526.10.0000	Free.
Crushed or powdered	2526.20.0000	Free.
Talc, steatite, and soapstone; cut or sawed	6815.99.2000	Free.

Depletion Allowance: Block steatite talc, 22% (domestic), 14% (foreign); other talc and pyrophyllite, 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Canada, China, and Pakistan were the principal sources of United States talc imports in recent years. Imports of talc and related materials were estimated to have decreased by 11% in 2024 compared with those in 2023. Imports from Pakistan decreased by about 42% in 2024 and accounted for about 56% of total imports. Imports from Canada decreased by 5% and accounted for 28% of the total. Imports from China decreased by approximately 57% and accounted for approximately 8% of total imports. Mexico, Canada, and China, in descending order of quantity, were the primary destinations for United States talc exports, collectively receiving about 77% of exports. Exports were estimated to have decreased slightly in 2024 compared with those in 2023.

A talc-mining company headquartered in New York announced in April 2024 that it completed the sale of its subsidiary talc business. The subsidiary had talc-mining and -processing facilities in Montana and Texas. These decisions were made in part owing to the talc industry's multiple legal disputes and concerns about the safety of talc used to manufacture certain products, such as baby powder and cosmetics.

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TALC AND PYROPHYLLITE

In August 2024, a global beauty brand headquartered in London, United Kingdom, filed for bankruptcy. Another company, a consumer products company headquartered in New Jersey, announced that it was filing bankruptcy for a third time in September. Both instances were owing to the increasing concerns and legal actions taken against the companies for the presence of asbestos in talcum powder used in popular products.

Ceramic tile and sanitaryware formulations and the technology for firing ceramic tile changed over recent decades, reducing the amount of talc required for the manufacture of some ceramic products. For paint, the industry shifted its focus to production of water-based paint (a product for which talc is not well suited because it is hydrophobic) from oil-based paint in order to reduce volatile emissions. The amount of talc used for paper manufacturing began to decrease beginning in the 1990s and some talc used for pitch control was replaced by chemical agents.

World Mine Production and Reserves: Reserve data for China were revised based on Government reports.

	Mine production[e]		Reserves[6]
	2023	2024	
United States (crude)	[7]508	530	140,000
Afghanistan	170	200	Large
Brazil (crude and beneficiated)[8]	[7]348	480	45,000
Canada (unspecified minerals)[8]	200	200	NA
China (unspecified minerals)	1,400	1,400	60,000
Finland	[7]197	200	Large
France (crude)	400	400	Large
India (steatite)[8]	1,440	1,400	110,000
Italy (includes steatite)	170	180	NA
Japan[8]	130	130	100,000
Korea, Republic of[8]	[7]307	310	81,000
Pakistan (steatite)	200	200	NA
South Africa[9]	200	320	NA
Turkey[8]	[7]233	250	15,000
Other countries (includes crude)[8]	807	650	Large
World total (rounded)	6,710	6,900	Large

World Resources:[7] The United States is self-sufficient in most grades of talc and related minerals, but lower priced imports have replaced domestic minerals for some uses. Talc occurs in the United States from New England to Alabama in the Appalachian Mountains and the Piedmont region, as well as in California, Montana, Nevada, Texas, and Washington. Domestic and world identified resources are estimated to be approximately five times the quantity of reserves.

Substitutes: Substitutes for talc include bentonite, chlorite, feldspar, kaolin, and pyrophyllite in ceramics; chlorite, kaolin, and mica in paint; calcium carbonate and kaolin in paper; bentonite, kaolin, mica, and wollastonite in plastics; and kaolin and mica in rubber.

[e]Estimated. E Net exporter. NA Not available.
[1]All statistics do not include pyrophyllite unless otherwise specified.
[2]Defined as sold by producers + imports – exports.
[3]Average ex-works unit value of milled talc sold by U.S. producers, based on data reported by companies.
[4]Includes only companies that mine talc or pyrophyllite. Excludes office workers and mills that process imported or domestically purchased material.
[5]Defined as imports – exports.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]Reported.
[8]Includes pyrophyllite.

TANTALUM

(Data in metric tons, tantalum content, unless otherwise specified)

Domestic Production and Use: Tantalum has not been mined in the United States since 1959. Domestic tantalum resources are low grade; some are mineralogically complex, and most are not commercially recoverable. Companies in the United States produced tantalum alloys, capacitors, carbides, compounds, and tantalum metal from imported tantalum ores and concentrates and tantalum-containing materials. Tantalum metal and alloys were recovered from foreign and domestic scrap. Domestic tantalum consumption was not reported by consumers. The value of tantalum consumed in 2024 was estimated to exceed $230 million as measured by the value of imports.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Mine	—	—	—	—	—
Secondary	NA	NA	NA	NA	NA
Imports for consumption[1]	1,200	1,330	1,720	1,110	1,300
Exports[1]	434	655	662	672	480
Shipments from Government stockpile[2]	−16	−10	—	NA	NA
Consumption, apparent[3]	753	663	1,060	[4]440	770
Price, tantalite, annual average, dollars per kilogram of Ta_2O_5 content[5]	158	158	196	170	170
Net import reliance[6] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Tantalum was recycled mostly from new scrap generated during the manufacture of tantalum-containing electronic components and from tantalum-containing cemented carbide and superalloy scrap. The amount of tantalum recycled was not available, but it may account for as much as 30% of consumption by domestic primary processors.

Import Sources (2020–23): Tantalum ores and concentrates: Australia, 58%; Congo (Kinshasa), 12%; Mozambique, 6%; United Arab Emirates, 5%; and other, 19%. Tantalum metal and powder: China,[7] 43%; Germany, 27%; Kazakhstan, 15%; Thailand, 5%; and other, 10%. Tantalum waste and scrap: Indonesia, 20%; Japan, 13%; Republic of Korea, 13%; China,[7] 12%; and other, 42%. Total: China,[7] 22%; Australia, 12%; Germany, 12%; Indonesia, 8%; and other, 46%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Synthetic tantalum-niobium concentrates	2615.90.3000	Free.
Niobium ores and concentrates	2615.90.6030	Free.
Tantalum ores and concentrates	2615.90.6060	Free.
Tantalum oxide	2825.90.9000	3.7% ad valorem.
Potassium fluorotantalate	2826.90.9000	3.1% ad valorem.
Tantalum, unwrought:		
Powders	8103.20.0030	2.5% ad valorem.
Alloys and metal	8103.20.0090	2.5% ad valorem.
Tantalum, waste and scrap	8103.30.0000	Free.
Tantalum, wrought:		
Crucibles	8103.91.0000	4.4% ad valorem.
Other	8103.99.0000	4.4% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile:[8]

	FY 2024		FY 2025	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Tantalum metal	24.04	0.09	29.26	0.09

Events, Trends, and Issues: U.S. tantalum apparent consumption was estimated to be 770 tons in 2024, a 75% increase from that in 2023, and estimated U.S. imports for consumption increased by 12% compared with those in 2023. The increase in U.S. tantalum imports in 2024 is a reflection of a broader trend in the global market, primarily owing to a recovery in demand from consumer electronics and data centers. Concurrently, estimated U.S. exports decreased by 29% in 2024. The value of primary metal imports had the most significant increase of 29% compared with that in 2023. In 2024, the average monthly price for tantalum ore was valued at $170 per kilogram of Ta_2O_5 content.

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TANTALUM

Since the CHIPS and Science Act was signed into law in 2022, the U.S. Department of Commerce announced as of October 2024 preliminary agreements with 20 companies for 32 semiconductor manufacturing projects in 20 States. In total, these projects have received almost $34 billion of the available $39 billion in direct funding and almost $29 billion in loans. The Department of Commerce planned to allocate the remaining funds to CHIPS and Science Act grantees by the end of 2024. As such, an expanded domestic chip manufacturing industry will increase demand for materials critical to semiconductor production, such as tantalum for capacitors and sputtering targets, to support the high volume of advanced chip fabrication.

In September, the Office of the United States Trade Representative announced final tariff modifications after completing its review of the actions imposed under section 301(b) of the Trade Act of 1974 (19 U.S.C. 2411, as amended): China's acts, policies, and practices related to technology transfer, intellectual property, and innovation. Additional categories of goods from China were subject to tariffs including a 25% ad valorem tariff on critical minerals, which included tantalum.

World Mine Production and Reserves:

	Mine production		Reserves[9]
	2023	2024[e]	
United States	—	—	—
Australia	44	52	[10]110,000
Bolivia	1	2	NA
Brazil	138	210	40,000
Burundi	[e]1	2	NA
China	[e]78	76	240,000
Congo (Kinshasa)	[e]920	880	NA
Ethiopia	[e]40	40	NA
Mozambique	51	55	NA
Nigeria	[e]390	390	NA
Russia	[e]23	29	NA
Rwanda	[e]350	350	NA
World total (rounded)	2,040	2,100	NA

World Resources:[9] Identified world resources of tantalum, most of which are in Australia, Brazil, Canada, and China, are considered adequate to supply projected needs. The United States has about 55,000 tons of tantalum resources in identified deposits, most of which were considered subeconomic at 2024 prices for tantalum.

Substitutes: The following materials can be substituted for tantalum, but a performance loss or higher costs may ensue: niobium and tungsten in carbides; aluminum, ceramics, and niobium in electronic capacitors; glass, molybdenum, nickel, niobium, platinum, stainless steel, titanium, and zirconium in corrosion-resistant applications; and hafnium, iridium, molybdenum, niobium, rhenium, and tungsten in high-temperature applications.

[e]Estimated. NA Not available. — Zero.

[1]Imports and exports include the estimated tantalum content of synthetic tantalum-niobium concentrates, niobium and tantalum ores and concentrates, tantalum waste and scrap, unwrought tantalum alloys and powder, and other tantalum articles. Synthetic concentrates and niobium ores and concentrates were assumed to contain 50% Ta_2O_5. Tantalum ores and concentrates were assumed to contain 32% Ta_2O_5. Niobium ores and concentrates were assumed to contain 28% Ta_2O_5. Ta_2O_5 is 81.897% tantalum.

[2]Defined as change in total inventory from prior yearend inventory. If negative, increase in inventory. Beginning in 2023, Government stock changes no longer available.

[3]Defined for 2020–22 as production + imports − exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.

[4]Decrease in apparent consumption is owing to a decline in imports for consumption caused by stockpiling in 2022.

[5]Sources: CRU Group (2020–21) and the Institute for Rare Earths and Metals (2022–24).

[6]Defined for 2020–22 as imports − exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.

[7]Includes Hong Kong.

[8]See Appendix B for definitions.

[9]See Appendix C for resource and reserve definitions and information concerning data sources.

[10]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 28,000 tons.

TELLURIUM

(Data in metric tons, tellurium content, unless otherwise specified)

Domestic Production and Use: Tellurium is recovered principally as a byproduct of the electrolytic refining of primary copper, where it accumulates in the residues of copper anodes. In 2024, two primary electrolytic copper refineries operated in the United States, one in Texas and one in Utah, and produced copper telluride from tellurium-bearing anode slimes. Tellurium was not refined in the United States; copper telluride from both U.S. facilities was exported for further processing. Downstream companies processed imported tellurium to manufacture high-purity tellurium products, tellurium compounds for specialty applications, and tellurium dioxide. Domestic tellurium production, consumption, and stocks were withheld to avoid disclosing company proprietary data.

Tellurium was used predominantly in the production of cadmium telluride (CdTe) for thin-film solar cells. Another significant end use was for the production of bismuth telluride (BiTe), which is used in thermoelectric devices for cooling and energy generation. Metallurgical uses were as an alloying additive in steel to improve machining characteristics, as a minor additive in copper alloys to improve machinability without reducing conductivity, in lead alloys to improve resistance to vibration and fatigue, in cast iron to control the depth of chill, and in malleable iron as a carbide stabilizer. Tellurium was used in the chemical industry as a vulcanizing agent and accelerator in the processing of rubber and as a component of catalysts for synthetic fiber production. Other uses included those in photoreceptor and thermoelectric devices, blasting caps, and as a pigment to produce various colors in glass and ceramics. In 2024, estimated end uses for tellurium in global consumption were solar power cells, 60%; thermoelectric devices, 20%; metallurgy, 15%; and other applications, 5%.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, copper telluride	W	W	W	W	W
Imports for consumption	12	42	37	8	7
Exports[1]	([2])	2	1	15	4
Consumption, apparent[3]	W	W	W	W	W
Price, annual average, dollars per kilogram:					
United States[4]	59.37	69.72	70.34	79.09	75
Europe[5]	56.05	67.26	68.10	76.74	80
Stocks, producer, yearend	W	W	W	W	W
Net import reliance[6] as a percentage of apparent consumption	>75	>95	>75	E	<25

Recycling: For traditional metallurgical and chemical applications, there was little or no scrap from which to extract secondary tellurium because these uses are highly dispersive or dissipative. A very small amount of tellurium was recovered from scrapped selenium-tellurium photoreceptors employed in older photocopiers in Europe. Tellurium was recycled from CdTe solar cells in the United States, but the amount recycled was limited because most CdTe solar cells were relatively new and had not reached the end of their useful life.

Import Sources (2020–23): Canada, 58%; Philippines, 19%; Japan, 9%; Germany, 5%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Tellurium	2804.50.0020	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The supply of tellurium is directly affected by the supply of materials from which it is a byproduct, primarily copper. In 2024, recovery of copper telluride from domestic copper anode slimes was estimated to have increased from that in 2023, reflecting greater output of copper cathode from electrolytic refineries in the United States. Owing to a well-supplied North American market, the annual average price for tellurium in U.S. warehouses decreased by 5% to an estimated $75 per kilogram in 2024 from $79.09 per kilogram in 2023. In Europe, limited availability of tellurium, steady demand, and higher costs of purchasing tellurium from China increased the annual average price by 4%, to an estimated $80 per kilogram in 2024 from $76.74 per kilogram in 2023.

The leading U.S. producer of solar modules opened its fourth domestic manufacturing facility in 2024 and was constructing a fifth plant that was projected to be commissioned in 2025. The company expected its solar panel production capacity in the United States to reach 14 gigawatts per year by the end of 2026.

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TELLURIUM

China was the leading producer of refined tellurium in 2024 and accounted for approximately 75% of estimated global output (excluding production in multiple countries for which available information was inadequate to make reliable estimates of output). Production in China increased significantly over the past 10 years, corresponding with an increase of about 60% in the production capacity of electrolytically refined copper. The production capacity of copper anode, the feedstock material for electrolytic copper refineries, nearly doubled over the same time period.

World Refinery Production and Reserves: The values shown for reserves reflect the estimated tellurium content of copper reserves except for those of China and Sweden, which represent reported reserves of tellurium. Reserves for Canada, Sweden, the United States, and "Other countries" were revised based on company and Government reports.

	Refinery production[7]		Reserves[8]
	2023	2024[e]	
United States (copper telluride)	W	W	3,800
Bulgaria	1	1	NA
Canada	[e]27	27	900
China	725	750	3,100
Japan	[e]65	70	NA
Russia	[e]73	70	5,800
South Africa	[e]4	4	800
Sweden (concentrates)	36	46	740
Uzbekistan	[e]13	13	NA
Other countries[9]	NA	NA	20,000
World total (rounded)	[10]944	[10]980	35,000

World Resources:[8] Reserves for tellurium are based on identified copper deposits and average tellurium content. More than 90% of tellurium has been produced from anode slimes as a byproduct of electrolytic copper refining, and the remainder was derived from skimmings at lead refineries and from flue dusts and gases generated during the smelting of bismuth, copper, and lead-zinc ores. Other potential sources of tellurium include bismuth telluride and gold telluride ores.

Substitutes: Several materials can replace tellurium in most of its uses, but usually with losses in efficiency or product characteristics. Amorphous silicon and copper indium gallium diselenide are the two principal competitors with CdTe in thin-film photovoltaic solar cells. Bismuth selenide and organic polymers can be used to substitute for BiTe in some thermoelectric devices. Bismuth, calcium, lead, phosphorus, selenium, and sulfur can be used in place of tellurium in many free-machining steels. Several of the chemical process reactions catalyzed by tellurium can be carried out with other catalysts or by means of noncatalyzed processes. In rubber compounding, sulfur and (or) selenium can act as vulcanization agents in place of tellurium. The selenides and sulfides of niobium and tantalum can serve as electrical-conducting solid lubricants in place of tellurides of those metals.

[e]Estimated. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]May include exports of copper telluride.
[2]Less than ½ unit. Export data reported by the U.S. Census Bureau in 2020 were adjusted by the U.S. Geological Survey.
[3]Defined as production (tellurium content of copper telluride) + imports – exports ± adjustments for industry stock changes.
[4]Minimum purity of 99.95%, free on board, U.S. warehouse. Source: Argus Media Group, Argus Non-Ferrous Markets.
[5]Minimum purity of 99.99%, in warehouse, Rotterdam. Source: Argus Media Group, Argus Non-Ferrous Markets.
[6]Defined as imports – exports ± adjustments for industry stock changes.
[7]Unless otherwise noted, data relate to refinery output only insofar as possible. Countries that produced tellurium contained in copper ore and concentrates, copper smelter products (blister and anodes), and (or) refinery residues but did not recover refined tellurium from these materials are excluded.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.
[9]In addition to the countries listed, Australia, Belgium, Chile, Germany, Indonesia, Kazakhstan, Mexico, and the Philippines may have produced refined tellurium, but available information was inadequate to make reliable estimates of output.
[10]Excludes U.S. production.

THALLIUM

(Data in kilograms unless otherwise specified)

Domestic Production and Use: There has been no domestic production of thallium since 1981. Small quantities are consumed annually, but variations in pricing and value complicate making accurate estimates of consumption value. The primary end uses included the following: radioisotope thallium-201 used for medical purposes in cardiovascular imaging; thallium used as an activator (sodium iodide crystal doped with thallium) in electronics for photoelectric cells and gamma radiation detection; thallium-barium-calcium-copper-oxide high-temperature superconductors; thallium used in lenses, prisms, and windows for infrared detection and transmission equipment; thallium-arsenic-selenium crystal filters used for light diffraction in acousto-optical measuring devices; and thallium used in mercury alloys for low temperature low-temperature thermometers and switches. Other uses include as an additive in glass to increase its refractive index and density, a catalyst for organic compound synthesis, a component in high-density liquids (thallium malonate formate or Clerici solution) for gravity separation of minerals.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production, refinery	—	—	—	—	—
Imports for consumption:					
Unwrought metal and metal powders	57	—	—	13	—
Waste and scrap	—	—	13	—	([1])
Other articles	—	7	—	[2]300	—
Exports:					
Unwrought metal and powders	300	190	—	1	—
Waste and scrap	359	—	—	—	—
Other articles	580	378	2,150	3,800	152
Consumption, estimated[3]	57	7	13	13	—
Price, metal, dollars per kilogram[e, 4]	8,200	8,400	9,400	8,800	9,500
Net import reliance[5] as a percentage of estimated consumption	NA	NA	NA	NA	NA

Recycling: None.

Import Sources (2020–2023): Mexico, 77%; Russia, 15%, France, 3%, Japan, 3%; and other, 2%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Unwrought and powders	8112.51.0000	4% ad valorem.
Waste and scrap	8112.52.0000	Free.
Other	8112.59.0000	4% ad valorem.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: As of September 2024, there were no reported imports or exports of unwrought thallium metal. However, according to data from the U.S. Census Bureau, a significant quantity of thallium waste and scrap (1,620 kilograms) was imported to Puerto Rico from the Dominican Republic in July 2024, marking a notable shift as this country had not been an import source in previous years. This was likely due to the misclassification of commodities such as medical devices or equipment containing thallium. Exports of thallium articles also decreased significantly to 152 kilograms in 2024 from 3,800 kilograms in 2023 and 2,150 kilograms in 2022. Data on inventory for domestic use remained unavailable.

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THALLIUM

The primary global uses for thallium include gamma radiation detection equipment, high-temperature superconductors, infrared optical materials, low-melting glass, photoelectric cells, and radioisotopes. Demand for thallium in medical nuclear imaging applications continued to decline owing to the superior performance and availability of alternatives, such as technetium-99m, although thallium was still used in certain cardiovascular stress tests. Research continued into innovative applications for thallium, including enhancements in scintillators for radiation detection and new thallium compounds for optoelectronic devices.

Thallium metal and its compounds are highly toxic materials and are strictly controlled to prevent harm to humans and the environment. Thallium and its compounds can enter the human body by skin contact, ingestion, or inhalation of dust or fumes. Under its national primary drinking water regulations, the U.S. Environmental Protection Agency has set an enforceable Maximum Contaminant Level of 2 parts per billion thallium in drinking water.

World Refinery Production and Reserves:[6] Thallium is produced commercially in only a few countries as a byproduct recovered from flue dust in the roasting of copper, lead, and zinc ores. Because most producers withhold thallium production data, global production data were limited. In 2023 (the latest year for which data were available), global production of thallium was estimated to be about 10,000 kilograms. China, Kazakhstan, and Russia were estimated to be leading producers of primary thallium. Substantial thallium-rich deposits have been identified in Brazil, China, North Macedonia, and Russia. Quantitative estimates of reserves were not available, owing to the difficulty in identifying deposits where thallium can be extracted economically. Previous estimates of reserves were based on the thallium content of zinc ores.

World Resources:[6] Although thallium is reasonably abundant in the Earth's crust, estimated at about 0.7 part per million, it exists mostly in association with potassium minerals in clays, granites, and soils, and it is not generally considered to be commercially recoverable from those materials. The major source of recoverable thallium is from trace amounts found in sulfide ores of copper, lead, zinc, and other metallic elements. As such, world resources of thallium are adequate to supply world requirements.

Substitutes: Although other materials and formulations can substitute for thallium in gamma radiation detection equipment and optics used for infrared detection and transmission, thallium materials are presently superior and more cost effective for these very specialized uses. The medical isotope technetium-99m can be used in cardiovascular-imaging applications instead of thallium. Nontoxic substitutes, such as tungsten compounds, are being marketed as substitutes for thallium in high-density liquids for gravity separation of minerals.

[e]Estimated. NA Not available. — Zero.

[1]Imports of thallium waste and scrap, HTS code 8112.52.000, were reported by the U.S. Census Bureau as 1,620 kilograms in 2024. However, this number may include material that may have been misclassified.

[2]Includes material that may have been misclassified.

[3]Estimated to be equal to imports for 2020–22 and 2024. In 2023, consumption was estimated to be equal to imports of unwrought metal and metal powders.

[4]Estimated average price of thallium 99.99%-pure granules in 100-gram lots from three retailers and producers as of October 31, 2024.

[5]Defined as imports – exports. Consumption and exports of unwrought thallium were from imported material or from a drawdown in unreported inventories.

[6]See Appendix C for resource and reserve definitions and information concerning data sources.

THORIUM

(Data in kilograms unless otherwise specified)

Domestic Production and Use: The world's primary source of thorium is the rare-earth and thorium phosphate mineral monazite. In 2024, monazite may have been produced as a separated concentrate or included as an accessory mineral in heavy-mineral concentrates, but thorium was not separated or recovered by any domestic facility. Essentially, all thorium compounds and alloys consumed by the domestic industry were derived from imports. The number of companies that processed or fabricated various forms of thorium for commercial use was not available. Thorium's use in most products was generally limited because of concerns over its naturally occurring radioactivity. Imports of thorium compounds are sporadic owing to changes in consumption and fluctuations in consumer inventory levels. The estimated value of thorium compounds imported for consumption by the domestic industry in 2024 was $120,000 (based on data through August 2024), compared with $928,000 in 2023.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production, mine (monazite)[1]	[2]960,000	W	W	W	W
Imports for consumption:					
Ore and concentrates (monazite)	3,000	16,000	—	—	—
Compounds (oxide, nitrate, and so forth)	1,920	5,790	1,930	13,300	4,400
Exports:					
Ore and concentrates (monazite)	958,000	—	22,000	—	—
Compounds (oxide, nitrate, and so forth)[3]	60,300	45,600	25,900	65,000	50,000
Consumption, apparent:[4]					
Ore and concentrates (monazite)	3,000	W	W	W	W
Compounds (oxide, nitrate, and so forth)	NA	NA	NA	NA	NA
Price, average unit value of imports, compounds, dollars per kilogram:[5]					
India	NA	NA	NA	74	NA
France	29	29	26	29	27
Net import reliance[6] as a percentage of apparent consumption	NA	NA	NA	NA	NA

Recycling: None.

Import Sources (2020–23): Ores and concentrates (monazite): China, 84%; and United Kingdom, 16%. Thorium compounds: India, 52%; France, 48%; and other, <1%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Thorium ore and concentrates (monazite)	2612.20.0000	Free.
Thorium compounds	2844.30.1000	5.5% ad valorem.

Depletion Allowance: Monazite, 22% on thorium content and 14% on rare-earth and yttrium content (domestic); 14% (foreign).

Government Stockpile: None.

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THORIUM

<u>Events, Trends, and Issues</u>: Domestic demand for thorium alloys, compounds, and metals was limited. In addition to research purposes, various commercial uses of thorium included catalysts, high-temperature ceramics, magnetrons in microwave ovens, metal-halide lamps, nuclear medicine, optical coatings, tungsten filaments, and welding electrodes.

Exports of unspecified thorium compounds were 44,100 kilograms through August 2024 with a unit value of $73 per kilogram. Owing to variations in the type and purity of thorium compounds, the unit value of exports can vary widely by month and by exporting customs district.

Globally, monazite was produced primarily for its rare-earth-element content, and only a small fraction of the byproduct thorium was recovered and consumed. Thorium consumption worldwide is relatively small compared with that of most other mineral commodities. In international trade, China was the leading importer of monazite; Nigeria, Madagascar, Thailand, and Indonesia were China's leading import sources, in descending order of quantity.

Several companies and countries were active in the pursuit of commercializing a new generation of nuclear reactors that would use thorium as a fuel material. Thorium-based nuclear research and development programs have been or were underway in Australia, Belgium, Brazil, Canada, China, Czechia, Denmark, Finland, France, Germany, India, Israel, Italy, Japan, the Republic of Korea, the Netherlands, Norway, Russia, the United Kingdom, and the United States.

<u>World Mine Production and Reserves</u>:[7] Production and reserves are associated with the recovery of monazite in heavy-mineral-sand deposits. Without demand for the rare earths, monazite likely would not be recovered for its thorium content under current market conditions.

<u>World Resources</u>:[7] The world's leading thorium resources are found in placer, carbonatite, and vein-type deposits. Thorium is found in several minerals, including monazite, thorianite, and thorite. According to the World Nuclear Association,[8] worldwide identified thorium resources were an estimated 6.4 million tons of thorium. Thorium resources are found throughout the world, most notably in Australia, Brazil, India, and the United States. India has the largest resources (850,000 tons), followed by Brazil (630,000 tons), and Australia and the United States (600,000 tons each).

<u>Substitutes</u>: Nonradioactive substitutes have been developed for many applications of thorium. Yttrium compounds have replaced thorium compounds in incandescent lamp mantles. A magnesium alloy containing lanthanides, yttrium, and zirconium can substitute for magnesium-thorium alloys in aerospace applications. Cerium, lanthanum, yttrium, and zirconium oxides can substitute for thorium in welding electrodes. Several replacement materials (such as yttrium fluoride and proprietary materials) are in use as optical coatings instead of thorium fluoride.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Monazite may have been produced as a separate concentrate or included as an accessory mineral in heavy-mineral concentrates.
[2]Estimated to be equal to exports.
[3]Includes material that may have been misclassified.
[4]Defined as production + imports – exports. Production is only for ore and concentrates. Monazite is produced for the production of rare-earth compounds and not for thorium recovery. The apparent consumption calculation for thorium compounds results in a negative value for thorium compounds.
[5]Calculated from U.S. Census Bureau import data.
[6]Defined as imports – exports; however, a meaningful net import reliance could not be calculated owing to uncertainties in the classification of material being imported and exported.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]Source: World Nuclear Association, 2017, Thorium: London, United Kingdom, World Nuclear Association, February.

TIN

(Data in metric tons, tin content, unless otherwise specified)

Domestic Production and Use: Tin has not been mined or smelted in the United States since 1993 or 1989, respectively. Twenty-five firms accounted for more than 93% of the primary tin consumed domestically in 2024. The uses for tin in the United States were tinplate, 23%; chemicals, 22%; solder, 11%; alloys, 10%; babbitt, brass and bronze, and tinning, 6%; bar tin, 2%; and other, 26%. In 2024, the estimated customs value of imported refined tin was $750 million, and the estimated value of tin recovered from old scrap domestically was $310 million based on the average S&P Global Platts Metals Week New York dealer price for tin.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, secondary:[e]					
Old scrap	9,320	9,430	9,420	9,430	10,000
New scrap	8,000	7,600	7,900	7,900	7,900
Imports for consumption:					
Refined	31,600	38,100	33,200	28,200	25,000
Tin alloys, gross weight	840	1,110	740	990	740
Tin waste and scrap, gross weight	20,700	18,600	11,600	10,700	9,500
Exports:					
Refined	519	1,290	1,310	918	560
Tin alloys, gross weight	1,130	630	531	652	1,400
Tin waste and scrap, gross weight	1,200	2,800	30,300	38,000	15,000
Shipments from Government stockpile, gross weight[1]	–7	437	—	NA	NA
Consumption, apparent, refined[2]	40,300	48,000	41,200	34,700	37,000
Price, average, cents per pound:[3]					
New York dealer	799	1,580	1,546	1,256	1,400
London Metal Exchange (LME), cash	777	1,478	1,423	1,177	1,400
Stocks, consumer and dealer, yearend	10,400	9,030	9,180	11,200	9,100
Net import reliance[4] as a percentage of apparent consumption, refined tin	77	80	77	73	73

Recycling: About 18,000 tons of tin from old and new scrap was estimated to have been recycled in 2024. Of this, about 10,000 tons was recovered from old scrap at 1 detinning plant and 31 secondary nonferrous-metal-processing plants, accounting for 27% of apparent consumption.

Import Sources (2020–23): Refined tin: Peru, 30%; Bolivia, 23%; Indonesia, 20%; Brazil, 11%; and other, 16%. Waste and scrap: Canada, 95%; Mexico, 4%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Unwrought tin:		
Tin, not alloyed	8001.10.0000	Free.
Tin alloys, containing, by weight:		
5% or less lead	8001.20.0010	Free.
More than 5% but not more than 25% lead	8001.20.0050	Free.
More than 25% lead	8001.20.0090	Free.
Tin waste and scrap	8002.00.0000	Free.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile:[5]

	FY 2024		FY 2025	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Tin (gross weight)	—	640	—	640

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TIN

Events, Trends, and Issues: The estimated amount of new and old scrap tin recycled domestically in 2024 increased by 3% compared with that in 2023. The estimated annual average New York dealer price for refined tin in 2024 was 1,400 cents per pound, an 11% increase compared with that in 2023. The estimated annual average LME cash price for refined tin in 2024 was 1,400 cents per pound, a 19% increase compared with that in 2023.

In 2024, the United States Department of Commerce proposed antidumping and countervailing duties on tin mill product imports from Canada, China, Germany, and the Republic of Korea following its investigation into dumping and subsidization. However, the U.S. International Trade Commission concluded that these imports did not materially injure the domestic tin mill products industry; therefore, the duties were not implemented. In September 2024, $19 million was awarded by the U.S. Department of Defense under the Defense Production Act, Title III, to establish a tin smelting, refining, and recycling facility in Coatesville, PA.

In April, a Uganda-based tin-mining company commissioned a tin refinery in Mbarara, Uganda. The refinery was expected to produce approximately 1,000 tons per year of more-than-99%-pure tin ingots. In May, a Mauritius-based company announced that it began production at its new processing plant in North Kivu Province, Congo (Kinshasa). Annual tin production was expected to increase to approximately 20,000 tons from the current 12,000 tons. In September, two state-owned leading refined-tin producers from China and Indonesia entered into a strategic partnership to collaborate in mining, smelting and refining, trading, and downstream product development.

World Mine Production and Reserves: Reserves for China and Vietnam were revised based on company and Government reports.

	Mine production		Reserves[6]
	2023	2024[e]	
United States	—	—	—
Australia	9,850	9,900	[7]620,000
Bolivia	18,700	21,000	400,000
Brazil	29,300	29,000	420,000
Burma	[e]34,000	34,000	700,000
China	[e]70,000	69,000	1,000,000
Congo (Kinshasa)	[e]20,000	25,000	120,000
Indonesia	[e]69,000	50,000	NA
Laos	[e]1,700	1,500	NA
Malaysia	3,770	3,000	NA
Nigeria	[e]7,000	7,000	NA
Peru	26,200	31,000	130,000
Russia	[e]2,700	3,000	460,000
Rwanda	[e]3,600	3,600	NA
Vietnam	[e]7,600	6,700	23,000
Other countries	1,840	1,800	310,000
World total (rounded)	305,000	300,000	>4,200,000

World Resources:[6] Identified resources of tin in the United States, primarily in Alaska, were insignificant compared with those in the rest of the world. World resources, principally in western Africa, southeastern Asia, Australia, Bolivia, Brazil, Indonesia, and Russia, are extensive and, if developed, could sustain recent annual production rates well into the future.

Substitutes: Aluminum, glass, paper, plastic, or tin-free steel substitute for tin in cans and containers. Other materials that substitute for tin are epoxy resins for solder; aluminum alloys, alternative copper-base alloys, and plastics for bronze; plastics for bearing metals that contain tin; and compounds of lead and sodium for some tin chemicals.

[e]Estimated. NA Not available. — Zero.
[1]Defined as change in inventory from prior yearend inventory. If negative, increase in inventory. Beginning in 2023, Government stock changes no longer available.
[2]Defined for 2020–22 as production from old scrap + refined tin imports – refined tin exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.
[3]Source: S&P Global Platts Metals Week.
[4]Defined for 2020–22 as refined imports – refined exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.
[5]See Appendix B for definitions.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 320,000 tons.

TITANIUM AND TITANIUM DIOXIDE[1]

(Data in metric tons unless otherwise specified)

Domestic Production and Use: Titanium sponge metal was produced by one operation in Utah. Production data were withheld to avoid disclosing company proprietary data. The facility in Salt Lake City, UT, with an estimated capacity of 500 tons per year, produced titanium that was further refined for use in electronics. A second sponge facility in Henderson, NV, with an estimated capacity of 12,600 tons per year, was idled since 2020 owing to market conditions. A third facility, in Rowley, UT, with an estimated capacity of 10,900 tons per year, has remained idle since 2016.

Although detailed 2024 consumption data were withheld to avoid disclosing proprietary data, the majority of titanium metal was used in aerospace applications, and the remainder was used in armor, chemical processing, marine hardware, medical implants, power generation, and other applications. The customs value of imported sponge was about $450 million, a 7% increase compared with $420 million in 2023.

In 2024, titanium dioxide (TiO_2) pigment production, by four companies operating five facilities in four States, was valued at an estimated $3 billion. The leading uses of TiO_2 pigment were, in descending order, paints (including lacquers and varnishes), plastics, and paper. Other uses of TiO_2 pigment included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Titanium sponge metal:					
Production	W	W	W	W	W
Imports for consumption[e]	19,200	16,000	30,900	40,400	40,000
Exports	711	117	105	247	90
Consumption, apparent[2]	W	[3]15,900	[3]30,800	[3]42,000	[3]40,000
Consumption, reported	W	W	W	W	W
Price, dollars per kilogram[4]	10.60	11.10	11.10	12.40	13
Stocks, industry, yearend[e]	W	W	W	W	W
Employment, number[e]	150	20	20	20	20
Net import reliance[5] as a percentage of apparent consumption	>50	>95	>95	>95	>95
TiO_2 pigment:					
Production	1,000,000	1,150,000	1,150,000	920,000	850,000
Imports for consumption	262,000	251,000	265,000	228,000	250,000
Exports	386,000	494,000	378,000	289,000	360,000
Consumption, apparent[2]	880,000	906,000	1,040,000	859,000	740,000
Price, dollars per metric ton[4]	2,710	2,920	3,450	3,240	3,200
Employment, number[e]	3,100	3,200	3,200	3,200	3,000
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Owing to limited responses from voluntary surveys, consumption data for titanium scrap metal for the titanium metal industry were withheld. Consumption data for titanium scrap for the steel, superalloy, and other industries were not available.

Import Sources (2020–23): Sponge metal: Japan, 82%; Kazakhstan, 9%; Saudi Arabia, 7%; and other, 2%. TiO_2 pigment: Canada, 44%; China, 12%; Germany, 8%; Mexico, 7%; and other, 29%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–24**
Titanium oxides (unfinished TiO_2 pigments)	2823.00.0000	5.5% ad valorem.
TiO_2 pigments, 80% or more TiO_2	3206.11.0000	6% ad valorem.
TiO_2 pigments, other	3206.19.0000	6% ad valorem.
Ferrotitanium and ferrosilicon titanium	7202.91.0000	3.7% ad valorem.
Unwrought titanium metal	8108.20.0000	15% ad valorem.
Titanium waste and scrap metal	8108.30.0000	Free.
Other titanium metal articles	8108.90.3000	5.5% ad valorem.
Wrought titanium metal	8108.90.6000	15% ad valorem.

Depletion Allowance: Not applicable.

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TITANIUM AND TITANIUM DIOXIDE

Government Stockpile:[6]

Material	FY 2024 Potential acquisitions	FY 2024 Potential disposals	FY 2025 Potential acquisitions	FY 2025 Potential disposals
Titanium	15,000	—	15,000	—
Titanium alloys	—	454	—	136

Events, Trends, and Issues: U.S. producers of titanium ingot and downstream products were reliant on imports of titanium sponge and scrap. U.S. imports of titanium sponge were an estimated 40,000 tons in 2024, near the historical high of 40,400 tons imported in 2023. Japan (67%), Saudi Arabia (23%), and Kazakhstan (7%) were the leading import sources for titanium sponge in 2024 through September.

With funding support from the U.S. Government, a company in Virginia was applying new technology to recycle scrap titanium metal to produce titanium powder. The company's immediate plans were to increase capacity from 2 tons per year to 125 tons per year and a long-term goal of reaching 10,000 tons per year by 2030.

U.S. imports of titanium scrap were estimated to be 28,000 tons in 2024. The United Kingdom (17%), Germany (12%), France and Japan (11% each), and Canada and the Republic of Korea (9% each) were the leading import sources for titanium waste and scrap in 2024 through September. In 2024, the annual average duty-paid unit value of scrap imports was about $8.70 per kilogram compared with $9.20 per kilogram in 2023.

Domestic production of TiO_2 pigment in 2024 was an estimated 850,000 tons. Although heavily reliant on imports of titanium mineral concentrates, the United States was a net exporter of TiO_2 pigments.

World Sponge Metal Production and Sponge and Pigment Capacity:

	Sponge production[e]		Capacity, 2024[e, 7]	
	2023	2024	Sponge	Pigment
United States	W	W	500	1,360,000
Australia	—	—	—	260,000
Canada	—	—	—	108,000
China	220,000	220,000	260,000	5,500,000
Germany	—	—	—	339,000
India	300	300	500	91,000
Japan	57,000	55,000	65,200	322,000
Kazakhstan	14,000	14,000	26,000	—
Mexico	—	—	—	350,000
Russia	20,000	20,000	46,500	55,000
Saudi Arabia	11,000	15,000	15,600	200,000
Ukraine	—	—	—	122,000
United Kingdom	—	—	—	315,000
Other countries	—	—	—	820,000
World total (rounded)	[8]320,000	[8]320,000	410,000	9,800,000

World Resources:[9] Resources of titanium minerals are discussed in the Titanium Mineral Concentrates chapter.

Substitutes: Few materials possess titanium metal's strength-to-weight ratio and corrosion resistance. In high-strength applications, titanium competes with aluminum, composites, intermetallics, steel, and superalloys. Aluminum, nickel, specialty steels, and zirconium alloys may be substituted for titanium for applications that require corrosion resistance. Ground calcium carbonate, precipitated calcium carbonate, kaolin, and talc compete with TiO_2 as a white pigment.

[e]Estimated. E Net exporter. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]See also the Titanium Mineral Concentrates chapter.
[2]Defined as production + imports – exports.
[3]Excludes domestic production of sponge in Utah.
[4]Landed duty-paid value based on U.S. imports for consumption.
[5]Defined as imports – exports.
[6]See Appendix B for definitions.
[7]Yearend operating capacity.
[8]Excludes U.S. production.
[9]See Appendix C for resource and reserve definitions and information concerning data sources.

TITANIUM MINERAL CONCENTRATES[1]

[Data in thousand metric tons, titanium dioxide (TiO_2) content, unless otherwise specified]

Domestic Production and Use: In 2024, one company recovered ilmenite and rutile concentrates from its surface-mining operations near Nahunta, GA, and Starke, FL. A second company processed existing mine tailings to recover a mixed heavy-mineral concentrate in California. A third company was in the process of commissioning a mine in Stony Creek, VA, that would produce ilmenite. Abrasive sands, monazite, and zircon were coproducts of domestic titanium minerals mining operations. Based on trade data through September, the estimated value of titanium mineral and synthetic concentrates imported into the United States in 2024 was $600 million. More than 95% of titanium mineral concentrates were consumed by domestic TiO_2 pigment producers. The remainder was used in welding-rod coatings and for manufacturing carbides, chemicals, and titanium metal.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production[2]	100	100	200	100	100
Imports for consumption	807	969	952	638	600
Exports, all forms[e]	18	30	110	40	5
Consumption, apparent[2, 3]	900	1,000	1,000	700	700
Price, dollars per metric ton:					
Rutile, bulk, minimum 95% TiO_2, free on board (f.o.b.) Australia[4]	1,170	1,300	1,470	1,460	1,310
Ilmenite and leucoxene, bulk, f.o.b. Australia[5]	459	595	530	389	500
Ilmenite, average unit value of imports[6]	215	240	285	365	340
Slag, 80%–95% TiO_2, average unit value of imports[6]	757	774	867	1,050	990
Employment, mine and mill, number	315	290	390	405	350
Net import reliance[7] as a percentage of apparent consumption	89	90	81	86	86

Recycling: None.

Import Sources (2020–23): South Africa, 32%; Madagascar, 16%; Canada, 13%; Australia, 11%; and other, 28%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Synthetic rutile	2614.00.3000	Free.
Ilmenite and ilmenite sand	2614.00.6020	Free.
Rutile concentrate	2614.00.6040	Free.
Titanium slag	2620.99.5000	Free.

Depletion Allowance: Ilmenite and rutile, 22% (domestic), 14% (foreign).

Government Stockpile: None.

Events, Trends, and Issues: Consumption of titanium mineral concentrates is closely tied to production of TiO_2 pigments that are primarily used in paint, paper, and plastics. Demand for these primary uses is related to changes in the gross domestic product. Although inventory changes were not included in the apparent consumption calculation, domestic apparent consumption of titanium mineral concentrates in 2024 was estimated to have remained level with that in 2023. Exports of titanium mineral concentrates decreased and included mixed concentrates derived from mine tailings.

As of September 2024, United States imports of titanium slag were predominantly from Canada (46%), Norway (31%), and South Africa (23%). Mozambique (38%), Madagascar (36%), and Senegal (22%) were leading sources of ilmenite, and South Africa (53%), Australia (29%), Kenya (8%), and Ukraine (8%) were the leading sources of rutile. All imports of synthetic rutile were from China.

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TITANIUM MINERAL CONCENTRATES

In 2024, China continued to be the leading producer and consumer of titanium mineral concentrates, accounting for approximately one-third of global production of ilmenite. Mozambique and South Africa also were major producers of titanium mineral concentrates. China's imports of titanium mineral concentrates for the year through October were 4.0 million tons in gross weight, a 14% increase compared with those in the same period in 2023. Mozambique (44%), Australia (12%), and Norway (9%) were the leading sources of titanium mineral concentrates to China.

World Mine Production and Reserves: Reserves for Canada, China, India, Kenya, Madagascar, Mozambique, and "Other countries" were revised based on company and Government reports.

	Mine production[e] 2023	Mine production[e] 2024	Reserves[8]
Ilmenite:			
United States[2, 9]	100	100	2,000
Australia	400	400	[10]180,000
Canada[11]	350	350	51,000
China	3,250	3,300	110,000
India	210	210	15,000
Madagascar[11]	300	240	30,000
Mozambique	1,860	1,900	NA
Norway	360	360	37,000
Senegal	260	300	NA
South Africa[11]	1,260	1,300	28,000
Ukraine	130	120	5,900
Other countries	360	330	>54,000
World total (ilmenite, rounded)[9]	8,840	8,900	>510,000
Rutile:			
United States	([9])	([9])	([9])
Australia	200	200	[10]35,000
India	12	12	670
Kenya	47	40	NA
Mozambique	8	8	720
Sierra Leone	110	60	2,900
South Africa	100	100	6,100
Ukraine	95	10	NA
Other countries	20	20	>540
World total (rutile, rounded)[9]	590	450	>46,000
World total (ilmenite and rutile, rounded)	9,430	9,400	>560,000

World Resources:[8] Ilmenite accounts for about 90% of the world's consumption of titanium minerals. World resources of anatase, ilmenite, and rutile total more than 2 billion tons.

Substitutes: Ilmenite, leucoxene, rutile, slag, and synthetic rutile compete as feedstock sources for producing TiO_2 pigment, titanium metal, and welding-rod coatings.

[e]Estimated. NA Not available.
[1]See also the Titanium and Titanium Dioxide chapter.
[2]Rounded to the nearest 100,000 tons to avoid disclosing company proprietary data.
[3]Defined as production + imports – exports.
[4]Source: Fastmarkets IM; annual average.
[5]Source: Zen Innovations AG, Global Trade Tracker.
[6]Landed duty-paid unit value based on U.S. imports for consumption. Source: U.S. Census Bureau.
[7]Defined as imports – exports.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.
[9]United States rutile production and reserves data are included with ilmenite.
[10]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were estimated to be 43 million tons for ilmenite and 11 million tons for rutile, respectively, TiO_2 content.
[11]Mine production of titaniferous magnetite is primarily used to produce titaniferous slag.

TUNGSTEN

(Data in metric tons, tungsten content, unless otherwise specified)

Domestic Production and Use: Tungsten has not been mined commercially in the United States since 2015. There were seven U.S. companies that have the capability to convert tungsten concentrates, ammonium paratungstate (APT), tungsten oxide, and (or) scrap to tungsten metal powder, tungsten carbide powder, and (or) tungsten chemicals. An estimated 60% of the tungsten consumed in the United States was used in cemented carbide parts for cutting and wear-resistant applications, primarily in the construction, metalworking, mining, and oil- and gas-drilling industries. The remainder was used to make various alloys and specialty steels; electrodes, filaments, wires, and other components for electrical, electronic, heating, lighting, and welding applications; and chemicals for various applications.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production:					
Mine	—	—	—	—	—
Secondary	W	W	W	W	W
Imports for consumption:					
Ores and concentrates	2,020	1,600	2,130	1,640	1,500
Other forms[1]	8,660	10,500	12,300	10,000	8,900
Exports:					
Ores and concentrates	480	441	614	1,510	2,000
Other forms[2]	2,470	2,970	3,680	3,180	3,700
Shipments from Government stockpile:[3]					
Concentrate	728	1,030	689	NA	NA
Other forms	34	93	—	NA	NA
Consumption:					
Reported, concentrate	W	W	W	W	W
Apparent,[4] all forms	W	W	W	W	W
Price,[5] concentrate, average in-warehouse Rotterdam, dollars per dry metric ton unit of tungsten trioxide[6]	172	225	275	258	250
Stocks, industry, concentrate and other forms, yearend	W	W	W	W	W
Net import reliance[7] as a percentage of apparent consumption	>50	>50	>50	>50	>50

Recycling: The estimated quantity of secondary tungsten produced and the amount consumed from secondary sources by processors and end users in 2024 were withheld to avoid disclosing company proprietary data.

Import Sources (2020–23): Ores, concentrates, and other forms:[1] China,[8] 27%; Germany, 14%; Bolivia, 8%; Vietnam, 8%; and other, 43%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Ores	2611.00.3000	Free.
Concentrates	2611.00.6000	37.5¢/kg on tungsten content.
Tungsten oxides	2825.90.3000	5.5% ad valorem.
Ammonium tungstates	2841.80.0010	5.5% ad valorem.
Tungsten carbides	2849.90.3000	5.5% ad valorem.
Ferrotungsten and ferrosilicon tungsten	7202.80.0000	5.6% ad valorem.
Tungsten powders	8101.10.0000	7% ad valorem.
Tungsten waste and scrap	8101.97.0000	2.8% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile:[9]

	FY 2024		FY 2025	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Ores and concentrates	—	907	—	499
Tungsten	266	—	2,041	—

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TUNGSTEN

Events, Trends, and Issues: World tungsten supply was dominated by Chinese production and exports. Tungsten concentrate production outside China was estimated to have increased in 2024 but remained around 20% of total world production, owing in part to the addition of two new operations in Australia. A project in the Republic of Korea was nearing production; additional projects outside of China were awaiting funding for further development. Scrap continued to be an important source of raw material for the tungsten industry. Tungsten consumption is strongly influenced by economic conditions and industrial activity. China continued to be the world's leading tungsten consumer. In September, the United States Trade Representative announced a section 301 tariff increase of 25% on imports of tungsten carbides, concentrates, oxides, powders, and tungstates from China. According to Argus Media Group, global tungsten consumption was estimated to have increased slightly from that in 2023.

World Mine Production and Reserves: Reserves for China, Portugal, and Vietnam were revised based on Government reports.

	Mine production[e]		Reserves[10]
	2023	2024	
United States	—	—	NA
Australia	430	1,000	[11]570,000
Austria	850	800	10,000
Bolivia	1,500	1,600	NA
China	66,000	67,000	2,400,000
Korea, North	1,600	1,700	29,000
Portugal	450	500	3,400
Russia	2,000	2,000	400,000
Rwanda	1,200	1,200	NA
Spain	650	700	66,000
Vietnam	3,500	3,400	140,000
Other countries	1,320	1,500	950,000
World total (rounded)	79,500	81,000	>4,600,000

World Resources:[10] World tungsten resources are geographically widespread. China ranked first in the world in terms of tungsten resources and reserves and had some of the largest deposits. Significant tungsten resources have been identified on every continent except Antarctica.

Substitutes: Potential substitutes for cemented tungsten carbides include cemented carbides based on molybdenum carbide, niobium carbide, or titanium carbide; ceramics; ceramic-metallic composites (cermets); and tool steels. Most of these options reduce rather than replace the amount of tungsten used. Potential substitutes for other applications are as follows: molybdenum for certain tungsten mill products; molybdenum steels for tungsten steels, although most molybdenum steels still contain tungsten; lighting based on carbon nanotube filaments, induction technology, and light-emitting diodes for lighting based on tungsten electrodes or filaments; depleted uranium or lead for tungsten or tungsten alloys in applications requiring high density or the ability to shield radiation; and depleted uranium alloys or hardened steel for cemented tungsten carbides or tungsten alloys in armor-piercing projectiles. In some applications, substitution would result in increased cost or a loss in product performance.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Includes ammonium and other tungstates; ferrotungsten; tungsten carbide powders; tungsten metal powders; tungsten oxides, chlorides, and other tungsten compounds; unwrought tungsten; wrought tungsten forms; and tungsten waste and scrap.
[2]Includes ammonium and other tungstates, ferrotungsten, tungsten carbide powders, tungsten metal powders, unwrought tungsten, wrought tungsten forms, and tungsten waste and scrap.
[3]Defined as change in total inventory from prior yearend inventory. If negative, increase in inventory. Beginning in 2023, Government stock changes no longer available.
[4]Defined for 2020–22 as mine production + secondary production + imports – exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.
[5]Source: Argus Media Group, Argus Tungsten Analytics.
[6]A metric ton unit of tungsten trioxide contains 7.93 kilograms of tungsten.
[7]Defined for 2020–22 as imports – exports ± adjustments for Government and industry stock changes. Beginning in 2023, Government stock changes no longer included.
[8]Includes Hong Kong.
[9]See Appendix B for definitions.
[10]See Appendix C for resource and reserve definitions and information concerning data sources.
[11]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 220,000 tons.

VANADIUM

(Data in metric tons, vanadium content, unless otherwise specified)

Domestic Production and Use: Vanadium production in Utah from the mining of uraniferous sandstones on the Colorado Plateau ceased in early 2020 and was not restarted in 2024. Secondary vanadium production continued in Arkansas, Delaware, Ohio, Pennsylvania, and Texas, where processed waste materials (petroleum residues, spent catalysts, and utility ash) were used to produce ferrovanadium, vanadium-bearing chemicals or specialty alloys, and vanadium pentoxide. Estimated U.S. apparent consumption of vanadium in 2024 decreased by 8% from that in 2023. Metallurgical use, primarily as an alloying agent for iron and steel, accounted for more than 90% of domestic reported vanadium consumption in 2024. Of the other uses for vanadium, the major nonmetallurgical use was in catalysts to produce maleic anhydride and sulfuric acid.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production from primary ore and concentrate	17	—	—	—	—
Production from ash, residues, and spent catalysts[e]	2,900	3,200	4,400	6,500	8,200
Imports for consumption:					
Aluminum-vanadium master alloy	101	35	104	221	110
Ash and residues[1, 2]	1,550	1,680	2,240	3,140	2,300
Ferrovanadium	1,360	2,170	2,650	2,280	1,800
Oxides and hydroxides, other	67	69	222	151	170
Vanadium chemicals[3]	382	846	804	793	530
Vanadium metal[4]	([5])	([5])	28	20	10
Vanadium ores and concentrates[1]	2	4	492	674	160
Vanadium pentoxide	1,670	1,710	1,980	2,320	2,500
Exports:					
Aluminum-vanadium master alloy	14	72	28	36	70
Ash and residues[1]	503	930	1,130	861	1,500
Ferrovanadium	210	173	154	159	70
Oxides and hydroxides, other	51	235	309	142	360
Vanadium metal[4]	1	4	8	38	5
Vanadium ores and concentrates[1]	92	81	185	82	20
Vanadium pentoxide	50	17	143	28	120
Consumption:					
Apparent[6]	7,110	8,200	11,000	14,800	14,000
Reported	7,920	8,030	7,510	[e]8,000	8,000
Price, average, vanadium pentoxide,[7] dollars per pound	6.47	8.17	9.29	7.50	5.45
Stocks, yearend[8]	269	271	248	240	250
Net import reliance[9] as a percentage of apparent consumption	59	61	60	56	40

Recycling: Recycling of vanadium is mainly associated with reprocessing vanadium catalysts into new catalysts. The range in vanadium content in spent catalysts varies depending on the crude oil feedstock and the uncertainty associated with the quantity of vanadium recycled from spent chemical process catalysts was significant.

Import Sources (2020–23): Ferrovanadium: Canada, 48%; Austria, 37%; Russia, 7%; and other, 8%. Vanadium pentoxide: Brazil, 49%; South Africa, 35%; Russia, 7%; and other, 9%. Total: Canada, 34%; Brazil, 13%; Austria, 11%; South Africa, 11%; and other, 31%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Vanadium ores and concentrates	2615.90.6090	Free.
Vanadium-bearing ash and residues	2620.40.0030	Free.
Vanadium-bearing ash and residues, other	2620.99.1000	Free.
Vanadium pentoxide, anhydride	2825.30.0010	5.5% ad valorem.
Vanadium oxides and hydroxides, other	2825.30.0050	5.5% ad valorem.
Ferrovanadium	7202.92.0000	4.2% ad valorem.
Vanadium metal	8112.92.7000	2% ad valorem.
Vanadium and articles thereof[10]	8112.99.2000	2% ad valorem.
Vanadium chemicals	([3])	5.5% ad valorem.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile: None.

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VANADIUM

Events, Trends, and Issues: The estimated average Chinese vanadium pentoxide (V_2O_5) price (98% V_2O_5 content) in 2024 was $5.45 per pound compared with $7.50 in 2023. The estimated United States ferrovanadium price (78%–82% vanadium content) was $12.84 per pound in 2024 compared with $16.42 in 2023. The World Steel Association estimated that global steel consumption increased by 1.7% in 2024. Total world steel production was estimated to have decreased by 1.5% during the first 7 months of 2024 compared with the same period in 2023. Like most ferroalloys, vanadium is largely dependent on the market characteristics of steel and specifically the Chinese steel industry. In 2024, China continued to be the world's top vanadium producer, producing most of its vanadium from vanadiferous iron ore processed for steel production.

Vanadium redox flow battery (VRFB) technology continued to be an increasingly important part of large-scale energy storage as it allows for high-safety, large-scale, environmentally friendly, medium- and long-term energy storage. Installations of VRFB projects continued to increase worldwide as energy companies looked to support renewable energy projects as many countries attempt to lower their carbon emissions. Many governments worldwide are promoting energy storage technologies, which creates favorable conditions for VRFB adoption. However, high capital and operating costs as well as limited vanadium feedstock availability remain the main drawback of VRFB technology. Despite the anticipated growth of VRFBs, there will be continued competition from a variety of alternative battery technologies looking to capture a portion of the energy storage market share.

World Mine Production and Reserves: Reserves for China and South Africa were revised based on company and Government reports.

	Mine production		Reserves[11]
	2023	2024[e]	(thousand metric tons)
United States	—	—	45
Australia	—	—	[12]8,500
Brazil	5,420	5,000	120
China	[e]70,000	70,000	4,100
Russia	[e]20,000	21,000	5,000
South Africa	8,670	8,000	430
World total (rounded)	104,000	100,000	18,000

World Resources:[11] World resources of vanadium exceed 63 million tons. Vanadium occurs in deposits of phosphate rock, titaniferous magnetite, and uraniferous sandstone and siltstone, in which it constitutes less than 2% of the host rock. Significant quantities are also present in bauxite and carboniferous materials, such as coal, crude oil, oil shale, and tar sands. Because vanadium is typically recovered as a byproduct or coproduct, demonstrated world resources of the element are not fully indicative of available supplies.

Substitutes: Steels containing various combinations of other alloying elements can be substituted for steels containing vanadium. Certain metals, such as manganese, molybdenum, niobium (columbium), titanium, and tungsten, are to some degree interchangeable with vanadium as alloying elements in steel. Platinum and nickel can replace vanadium compounds as catalysts in some chemical processes. Currently, no acceptable substitute for vanadium is available for use in aerospace titanium alloys.

[e]Estimated. — Zero.
[1]Reported by the U.S. Census Bureau as kilograms of V_2O_5. To convert V_2O_5 content to vanadium content, multiply by 0.56.
[2]Includes estimates for data suppressed by the U.S. Census Bureau in the years 2020 through 2024.
[3]Includes Harmonized Tariff Schedule of the United States codes for chloride oxides and hydroxides of vanadium (2827.49.1000), hydrides and nitrides of vanadium (2850.00.2000), vanadates (2841.90.1000), vanadium chlorides (2827.39.1000), and vanadium sulfates (2833.29.3000).
[4]Includes waste and scrap.
[5]Less than ½ unit.
[6]Defined as primary production + secondary production + imports – exports ± adjustments for industry stock changes.
[7]Chinese annual average V_2O_5 prices (98% V_2O_5 content). Source Argus Media Group, Argus Non-Ferrous Markets.
[8]Includes ferrovanadium, vanadium-aluminum alloy, other vanadium alloys, vanadium metal, vanadium pentoxide, and other specialty chemicals.
[9]Defined as imports – exports ± adjustments for industry stock changes.
[10]Aluminum-vanadium master alloy consisting of 35% aluminum and 64.5% vanadium and is the main master alloy for the vanadium industry. Unwrought aluminum-vanadium master alloy (Harmonized Tariff Schedule of the United States code 7601.20.9030) was not included.
[11]See Appendix C for resource and reserve definitions and information concerning data sources.
[12]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 3 million tons.

VERMICULITE

(Data in thousand metric tons unless otherwise specified)

Domestic Production and Use: Two companies with mining and processing facilities in South Carolina and Virginia produced approximately 100,000 tons of vermiculite concentrate; data have been rounded to the nearest hundred thousand tons to avoid disclosing company proprietary data. Flakes of raw vermiculite concentrate are micaceous in appearance and contain interlayer water in their structure. When the flakes are heated rapidly to a temperature above 870 degrees Celsius, the water flashes into steam, and the flakes expand into accordionlike particles. This process is called exfoliation or expansion, and the resulting ultralightweight material is chemically inert, fire resistant, and odorless. Most vermiculite concentrate, whether produced in the United States or imported, was shipped to 13 exfoliating plants in eight States. The end uses for exfoliated vermiculite were estimated to be agriculture and horticulture, 29%; lightweight concrete aggregates (including cement premixes, concrete, and plaster) and insulation, 16% each; and other, 39%.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production[1, 2]	100	100	100	100	100
Imports for consumption[e]	40	32	24	50	60
Exports[e]	8	10	8	8	8
Consumption:					
Apparent, concentrate[e, 3]	130	120	120	140	150
Reported, exfoliated	74	68	67	59	70
Price, range of value, concentrate, ex-plant, dollars per metric ton	NA	NA	NA	NA	NA
Employment, number[e]	70	70	70	70	70
Net import reliance[4] as a percentage of apparent consumption[e]	[5]20	18	14	30	34

Recycling: Insignificant.

Import Sources (2020–23): South Africa, 51%; Brazil, 42%; Zimbabwe, 5%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Vermiculite, perlite, and chlorites, unexpanded	2530.10.0000	Free.
Exfoliated vermiculite, expanded clays, foamed slag, and similar expanded materials	6806.20.0000	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Trade data for vermiculite concentrate are collected within the group "vermiculite, perlite and chlorites, unexpanded" by the U.S. Census Bureau. Domestic exports and imports for consumption of vermiculite were estimated based on information published by the U.S. Census Bureau and adjusted by the U.S. Geological Survey based on average unit value, countries known to produce vermiculite, and likely port destinations to eliminate other minerals reported in the same group. United States imports were an estimated 60,000 tons in 2024, compared with an estimated 50,000 tons in 2023. In 2024, most imports came from Brazil and South Africa.

Demand for all grades of vermiculite was stable. Exploration and development of vermiculite deposits containing medium, large, and premium (coarser) grades are likely to continue because of the higher demand for those grades. Producers are expected to continue investigating ways to increase the use of the finer grades in existing products and as a substitute for coarser grade vermiculite while continuing to develop new and innovative applications.

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VERMICULITE

World Mine Production and Reserves:

	Mine production		Reserves[6]
	2023	2024[e]	
United States	[1, 2]100	[1, 2]100	25,000
Brazil	53	60	6,600
Bulgaria	[e]10	10	NA
China	[e]33	30	2,900
India	2	2	1,600
Russia	[e]29	30	NA
South Africa	170	170	14,000
Turkey	11	10	11,000
Uganda	[e]23	20	NA
Zimbabwe	28	30	NA
World total (rounded)	458	460	NA

World Resources:[6] In addition to the producing mines in South Carolina and Virginia, there are vermiculite occurrences in Colorado, Nevada, North Carolina, Texas, and Wyoming that contain estimated resources of 2 million to 3 million tons. Significant deposits have been reported in Australia, Russia, Uganda, and some other countries, but reserve and resource information comes from many sources, and in most cases, it is not clear whether the numbers refer to vermiculite alone or vermiculite plus other minerals and host rock and overburden.

Substitutes: Expanded perlite is a substitute for exfoliated vermiculite in lightweight concrete and plaster. Other denser but less costly alternatives in these applications include expanded clay, shale, slag, and slate. Alternate materials for loose-fill fireproofing insulation include fiberglass, perlite, and slag wool. In agriculture, substitutes include bark and other plant materials, peat, perlite, sawdust, and synthetic soil conditioners.

[e]Estimated. NA Not available.
[1]Concentrate sold or used by producers.
[2]Data are rounded to the nearest hundred thousand tons to avoid disclosing company proprietary data.
[3]Defined as concentrate sold or used by producers + imports – exports.
[4]Defined as imports – exports.
[5]Data are rounded to one significant digit to avoid disclosing company proprietary data.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.

WOLLASTONITE

(Data in metric tons unless otherwise specified)

Domestic Production and Use: Wollastonite was mined by two companies in New York during 2024. U.S. production of wollastonite (sold or used by producers) was withheld to avoid disclosing company proprietary data but was estimated to have decreased from that in 2023. Economic resources of wollastonite typically form as a result of thermal metamorphism of siliceous limestone during regional deformation or chemical alteration of limestone by siliceous hydrothermal fluids along faults or contacts with magmatic intrusions. Deposits of wollastonite have been identified in Arizona, California, Idaho, Nevada, New Mexico, New York, and Utah; however, New York is the only State where long-term continuous mining has taken place.

Ceramics (frits, sanitaryware, and tile), friction products (primarily brake linings), metallurgical applications (flux and conditioner), paint (architectural and industrial paints), plastics and rubber markets (thermoplastic and thermoset resins and elastomer compounds), and miscellaneous uses (including adhesives, concrete, glass, and sealants) accounted for wollastonite sales in the United States.

In ceramics, wollastonite decreases shrinkage and gas evolution during firing; increases green and fired strength; maintains brightness during firing; permits fast firing; and reduces crazing, cracking, and glaze defects. In metallurgical applications, wollastonite serves as a flux for welding, a source for calcium oxide, a slag conditioner, and protects the surface of molten metal during the continuous casting of steel. As an additive in paint, it improves the durability of the paint film, acts as a pH buffer, improves resistance to weathering, reduces gloss and pigment consumption, and acts as a flatting and suspending agent. In plastics, wollastonite improves tensile and flexural strength, reduces resin consumption, and improves thermal and dimensional stability at elevated temperatures. Surface treatments are used to improve the adhesion between wollastonite and the polymers to which it is added. As a substitute for asbestos in floor tiles, friction products, insulating board and panels, paint, plastics, and roofing products, wollastonite is resistant to chemical attack, stable at high temperatures, and improves flexural and tensile strength.

Salient Statistics—United States: The United States was a net exporter of wollastonite in 2024. Comprehensive trade data were not available for wollastonite because it is imported and exported under a generic Harmonized Tariff Schedule of the United States code and Schedule B number, respectively, that include multiple mineral commodities. Price data for wollastonite were unavailable. Products with finer grain sizes and acicular (highly elongated) particles sold for higher prices. Surface treatment, when necessary, also increased the selling price. Approximately 65 people were employed at wollastonite mines and mills in 2024 (excluding office workers) in the United States.

Recycling: None.

Import Sources (2020–23): Comprehensive trade data were not available, but wollastonite was primarily imported from China and India.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Mineral substances not elsewhere specified or included	2530.90.8050	Free.

Depletion Allowance: 10% (domestic and foreign).

Government Stockpile: None.

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WOLLASTONITE

Events, Trends, and Issues: In March 2024, the U.S. Environmental Protection Agency (EPA) issued a final rule[1] that prohibited the commercial use, distribution in commerce, import, manufacturing, and processing of chrysotile for all asbestos-containing products that are still used in the United States: aftermarket automotive brakes and linings and other vehicle friction products, diaphragms used in the chloralkali industry, oilfield brake blocks, and sheet and other gaskets. The EPA ordered most uses of asbestos to cease from 6 months to 2 years after the effective date of the rule. This could lead to greater use of wollastonite in brake and friction products as a substitute for asbestos.

The production of motor vehicles and parts, which contain wollastonite in friction products and plastic and rubber components, decreased by 13% in the first 7 months of 2024 compared with the first 7 months of 2023. Construction starts of new housing units through August 2024 decreased by 4% compared with those during the same period in 2023. Sales of wollastonite to domestic construction-related markets, such as adhesives, caulks, cement board, ceramic tile, paints, stucco, and wallboard, were estimated to have decreased. Sales of wollastonite were estimated to be slightly lower for primary iron and steel production, which decreased slightly in the first 7 months of 2024 compared with production during the same period in 2023.

Globally, ceramics, paint, and polymers (such as plastics and rubber) accounted for most wollastonite sales. Lesser global uses for wollastonite included miscellaneous construction products, friction materials, metallurgical applications, and paper. Several research projects continued in Canada, India, and the United States to evaluate the efficacy of wollastonite in carbon dioxide sequestration. Studies were being conducted to evaluate wollastonite's ability to capture atmospheric carbon dioxide when added to crop fields and its ability to enhance crop productivity. Wollastonite's ability to reduce carbon dioxide emissions in cement production by lowering kiln temperatures needed to produce cement and absorbing carbon dioxide in the process was being evaluated.

World Mine Production and Reserves: More countries than those listed may produce wollastonite; however, many countries do not publish wollastonite production data.

	Mine production[e]		Reserves[2]
	2023	2024	
United States	W	W	World resources of wollastonite were estimated to exceed 100 million tons. Many deposits have been identified but have not been surveyed sufficiently to quantify their reserves.
Canada	20,000	20,000	
China	770,000	800,000	
Finland	10,000	10,000	
India	115,000	120,000	
Mexico	89,200	95,000	
Other countries	10,000	10,000	
World total (rounded)[3]	1,010,000	1,100,000	

World Resources:[2] Reliable estimates of wollastonite resources do not exist for most countries. Large deposits of wollastonite have been identified in China, Finland, India, Mexico, and the United States. Smaller, but significant, deposits have been identified in Canada, Chile, Kenya, Namibia, South Africa, Spain, Sudan, Tajikistan, Turkey, and Uzbekistan.

Substitutes: The acicular nature of many wollastonite products allows wollastonite to compete with other acicular materials, such as ceramic fiber, glass fiber, steel fiber, and several organic fibers, such as aramid, polyethylene, polypropylene, and polytetrafluoroethylene, in products where improvements in dimensional stability, flexural modulus, and heat deflection are sought. Wollastonite also competes with several nonfibrous minerals or rocks, such as kaolin, mica, and talc, which are added to plastics to increase flexural strength, and such minerals as barite, calcium carbonate, gypsum, and talc, which impart dimensional stability to plastics. In ceramics, wollastonite competes with carbonates, feldspar, lime, and silica as a source of calcium and silica. Its use in ceramics depends on the formulation of the ceramic body and the firing method.

[e]Estimated. W Withheld to avoid disclosing company proprietary data.

[1]Source: U.S. Environmental Protection Agency, 2024, Asbestos part 1—Chrysotile asbestos—Regulation of certain conditions of use under the Toxic Substances Control Act (TSCA): Federal Register, v. 89, no. 61, March 28, p. 21970–22010. (Accessed September 29, 2024, at https://www.govinfo.gov/content/pkg/FR-2024-03-28/pdf/2024-05972.pdf.) See also the Asbestos Chapter.

[2]See Appendix C for resource and reserve definitions and information concerning data sources.

[3]Excludes U.S. production.

YTTRIUM[1]

[Data in metric tons, yttrium oxide (Y_2O_3) equivalent, unless otherwise specified]

Domestic Production and Use: Yttrium is one of the rare-earth elements. Bastnaesite (or bastnäsite), a rare-earth fluorocarbonate mineral, was mined in 2024 as a primary product at the Mountain Pass Mine in California, which was restarted in the first quarter of 2018 after being put on care-and-maintenance status in the fourth quarter of 2015. Yttrium was estimated to represent about 0.12% of the rare-earth elements in the Mountain Pass bastnaesite ore. Insufficient information was available to determine the yttrium content of the bastnaesite ore production. Monazite, a rare-earth phosphate mineral, was produced as a separated concentrate that includes yttrium-rich xenotime as part of heavy-mineral-sand concentrates in Florida. There was no fully commercial rare-earth separation facility in the United States, and rare-earth concentrates were exported for processing.

The leading end uses of yttrium were in catalysts, ceramics, electronics, lasers, metallurgy, and phosphors. In ceramic applications, yttrium compounds were used in abrasives, bearings and seals, high-temperature refractories for continuous-casting nozzles, jet-engine coatings, oxygen sensors in automobile engines, and wear-resistant and corrosion-resistant cutting tools. In electronics, yttrium-iron garnets were components in microwave radar to control high-frequency signals. Yttrium was an important component in yttrium-aluminum-garnet laser crystals used in dental and medical surgical procedures, digital communications, distance and temperature sensing, industrial cutting and welding, nonlinear optics, photochemistry, and photoluminescence. In metallurgical applications, yttrium was used as a grain-refining additive and as a deoxidizer. Yttrium was used in heating-element alloys, high-temperature superconductors, and superalloys. Yttrium was used in phosphor compounds for flat-panel displays and various lighting applications.

Salient Statistics—United States:	**2020**	**2021**	**2022**	**2023**	**2024[e]**
Production, mine	NA	NA	NA	NA	NA
Imports for consumption, yttrium, alloys, compounds, and metal[e, 2]	650	670	1,200	250	470
Exports, compounds[e, 3]	1	9	4	20	[4]3
Consumption, apparent[e, 5]	600	700	1,000	200	500
Price, average, dollars per kilogram:[6]					
Y_2O_3, minimum 99.999% purity	3	6	12	8	6
Yttrium metal, minimum 99.9% purity	34	39	41	33	33
Net import reliance[7, 8] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Insignificant.

Import Sources (2020–23):[9] Yttrium compounds: China,[10] 93%; Germany, 3%; and other, 4%. Nearly all imports of yttrium metal and compounds are derived from mineral concentrates processed in China. Import sources do not include yttrium contained in value-added intermediates and finished products.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–24**
Rare-earth metals, unspecified:		
Not alloyed	2805.30.0050	5% ad valorem.
Alloyed	2805.30.0090	5% ad valorem.
Mixtures of rare-earth oxides containing yttrium or scandium as the predominant metal	2846.90.2015	Free.
Mixtures of rare-earth chlorides containing yttrium or scandium as the predominant metal	2846.90.2082	Free.
Yttrium-bearing materials and compounds containing by weight >19% to <85% Y_2O_3	2846.90.4000	Free.
Other rare-earth compounds, including yttrium and other compounds	2846.90.8090	3.7% ad valorem.

Depletion Allowance: Monazite, thorium content, 22% (domestic), 14% (foreign); yttrium, rare-earth content, 14% (domestic and foreign); and xenotime, 14% (domestic and foreign).

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YTTRIUM

Government Stockpile: Not available.

Events, Trends, and Issues: China produced most of the world's supply of yttrium from its weathered clay ion-adsorption ore deposits in the southern Provinces—primarily Fujian, Guangdong, and Jiangxi—and from a lesser number of deposits in Guangxi and Hunan. Yttrium also was produced from similar clay deposits in Burma.

Globally, yttrium was mainly consumed in the form of oxide compounds for ceramics and phosphors. Lesser amounts were consumed in electronic devices, lasers, optical glass, and metallurgical applications. In 2024, the average price for Y_2O_3 decreased whereas the average price for yttrium metal remained the same as that in 2023. China's Ministry of Industry and Information Technology raised quotas for rare-earth mining and separation in 2024 to 270,000 tons and 250,000 tons of rare-earth-oxide equivalent, respectively. The yttrium content of the production quota was not specified. Mine production quotas allocated 250,850 tons to light rare earths and 19,150 tons to ion-adsorption clays. In 2024, China exported an estimated 3,100 tons (Y_2O_3 equivalent) of yttrium compounds and metal, and the leading export destinations were, in descending order, Japan, the United States, the Netherlands, and the Republic of Korea.

World Mine Production and Reserves:[11] World mine production of Y_2O_3 equivalent contained in rare-earth mineral concentrates was estimated to be 15,000 to 20,000 tons. Most of this production took place in China and Burma. Global reserves of Y_2O_3 were not quantified; however, the leading countries for total rare-earth-oxide reserves included Australia, Brazil, China, India, Russia, and Vietnam. Although mine production in Burma was significant, information on reserves in Burma was not available. Global reserves may be adequate to satisfy near-term demand at current rates of production; however, recent high demand of ion-adsorption clay rare earths in Burma and China as well as changes in economic conditions, environmental issues, or permitting and trade restrictions could affect the availability and pricing of many of the rare-earth elements, including yttrium.

World Resources:[11] Large resources of yttrium in monazite and xenotime are available worldwide in placer deposits, carbonatites, uranium ores, and weathered clay deposits (ion-adsorption ore). Additional resources of yttrium occur in apatite-magnetite-bearing rocks, deposits of niobium-tantalum minerals, non-placer monazite-bearing deposits, sedimentary phosphate deposits, and uranium ores.

Substitutes: Substitutes for yttrium are available for some applications but generally are much less effective. In most uses, especially in electronics, lasers, and phosphors, yttrium is generally not subject to direct substitution by other elements. As a stabilizer in zirconia ceramics, Y_2O_3 may be substituted with calcium oxide or magnesium oxide, but the substitutes generally impart lower toughness.

[e]Estimated. NA Not available.
[1]See also the Rare Earths chapter; trade data for yttrium are included in the data shown for rare earths.
[2]Estimated from Trade Mining LLC shipping records.
[3]Includes data for the following Schedule B number: 2846.90.2015.
[4]Data adjusted by the U.S. Geological Survey to exclude low-value shipments. The U.S. Census Bureau reported 731,000 metric tons of exports through September 2024.
[5]Defined as imports – exports. Rounded to one significant digit. Yttrium consumed domestically was imported or refined from imported materials.
[6]Free on board China. Source: Argus Media Group, Argus Rare Earths.
[7]Defined as imports – exports.
[8]Domestic production of mineral concentrates was stockpiled or exported. Consumers of compounds and metals were reliant on imports and stockpiled inventory of compounds and metals.
[9]Includes estimated Y_2O_3 equivalent from the following Harmonized Tariff Schedule of the United States codes: 2846.90.2015, 2846.90.2082, 2846.90.4000, 2846.90.8050, and 2846.90.8060 (2020–21); and 2846.90.8075 and 2846.90.8090 (2022–23).
[10]Includes Hong Kong.
[11]See Appendix C for resource and reserve definitions and information concerning data sources.

ZEOLITES (NATURAL)

(Data in metric tons unless otherwise specified)

Domestic Production and Use: In 2024, seven companies operated nine zeolite mines in six States and produced an estimated 81,000 tons of natural zeolites. Total production increased by 3% compared with production in 2023. Chabazite was mined in Arizona and clinoptilolite was mined in California, Idaho, New Mexico, Oregon, and Texas. Small quantities of erionite, ferrierite, mordenite, and phillipsite were also likely produced.

An estimated 73,000 tons of natural zeolites were sold in the United States during 2024, 4% less than the sales in the previous year. Domestic uses were, in descending order of estimated quantity, animal feed, odor control, unspecified end uses (such as ice melt, soil amendment, and synthetic turf), water purification, wastewater treatment, gas absorbent, fertilizer carrier, pet litter, oil and grease absorbent, fungicide or pesticide carrier, desiccant, aquaculture, and catalyst. Animal feed and odor control accounted for 46% and 12%, respectively, of the domestic sales tonnage.

Salient Statistics—United States:	2020	2021	2022	2023[e]	2024[e]
Production, mine	86,700	87,000	77,400	78,000	81,000
Sales, mill	75,300	73,900	79,800	76,000	73,000
Imports for consumption[e]	<1,000	<1,000	<1,000	<1,000	<1,000
Exports[e]	<1,000	<1,000	<1,000	<1,000	<1,000
Consumption, apparent[1]	75,300	73,900	79,800	76,000	73,000
Price, range of value, dollars per metric ton[e, 2]	50–300	50–300	50–300	50–300	50–300
Employment, mine and mill, number[e, 3]	120	120	130	130	130
Net import reliance[4] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Zeolites used for desiccation, gas absorbance, wastewater treatment, and water purification may be reused after reprocessing of the spent zeolites. Information about the quantity of recycled natural zeolites was unavailable.

Import Sources (2021–24): Comprehensive trade data were not available for natural zeolite minerals because they were imported and exported under a generic Harmonized Tariff Schedule of the United States code and Schedule B number, respectively, that include multiple mineral commodities or under codes for finished products. Nearly all imports and exports were estimated to be synthetic zeolites.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Mineral substances not elsewhere specified or included	2530.90.8050	Free.

Depletion Allowance: 14% (domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Production and sales of natural zeolites have more than doubled from 1993 through 2024 owing to increased sales for animal feed, odor control, soil amendment, and water purification applications. Domestic production and sales of natural zeolite products have fluctuated in recent years. Natural zeolite sales decreased for the second year in a row after reaching a 5-year high in 2022. Sales for natural zeolites have fluctuated over the past few years owing to a shift in zeolite markets and competition from other products such as clays and synthetic zeolites. The change from traditional sales markets such as pet litter to newer markets (traction control, soil amendment, and artificial turf infill) has generated more variance in production and sales volumes.

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ZEOLITES (NATURAL)

World Mine Production and Reserves: Many countries either do not report production of natural zeolites, report zeolites as part of a pooled group of mineral commodities often listed as "other," or report production with a 2- to 3-year time delay. End uses for natural zeolites in countries that mine large tonnages of zeolite minerals typically include low-value, high-volume construction applications, such as dimension stone, lightweight aggregate, and pozzolanic cement. As a result, production data for some countries may not be comparable to U.S. production data, which are the quantities of natural zeolites used in high-value applications.

World reserves of natural zeolites have not been estimated. Deposits occur in many countries, but companies rarely publish reserves data. Further complicating estimates of reserves is that much of the reported world production includes altered volcanic tuffs with low to moderate concentrations of zeolites that are typically used in high-volume construction applications. Some deposits should, therefore, be excluded from reserves estimates because it is the rock itself and not its zeolite content that makes these deposits valuable.

	Mine production		Reserves[5]
	2023	2024[e]	
United States	[e]78,000	81,000	Two of the leading companies in the United States reported combined reserves of 80 million metric tons in 2022; total U.S. reserves likely were substantially larger. World data were unavailable, but reserves were estimated to be large.
Chile	500	500	
China	[e]150,000	150,000	
Cuba	[e]78,000	78,000	
Georgia	3,600	5,000	
Hungary	[e]32,000	35,000	
Indonesia	[e]120,000	120,000	
Jordan	[e]1,000	1,000	
Korea, Republic of	178,000	130,000	
New Zealand	[e]100,000	100,000	
Philippines	3,260	7,100	
Russia	[e]35,000	35,000	
Slovakia	207,000	220,000	
Turkey	71,700	70,000	
World total (rounded)	1,060,000	1,000,000	

World Resources:[5] Recent estimates for domestic and global resources of natural zeolites are not available. Resources of chabazite and clinoptilolite in the United States are sufficient to satisfy foreseeable domestic demand.

Substitutes: For pet litter, zeolites compete with other mineral-based litters, such as those manufactured using bentonite, diatomite, fuller's earth, and sepiolite; organic litters made from shredded corn stalks and paper, straw, and wood shavings; and litters made using silica gel. Diatomite, perlite, pumice, vermiculite, and volcanic tuff compete with natural zeolites as lightweight aggregate. Zeolite desiccants compete against such products as magnesium perchlorate and silica gel. Zeolites compete with bentonite, gypsum, montmorillonite, peat, perlite, silica sand, and vermiculite in various soil amendment applications. Activated carbon, diatomite, or silica sand may substitute for zeolites in water-purification applications. As an oil absorbent, zeolites compete mainly with bentonite, diatomite, fuller's earth, sepiolite, and a variety of polymer and natural organic products. In animal feed, zeolites compete with bentonite, diatomite, fuller's earth, kaolin, silica, and talc as anticaking and flow-control agents.

[e]Estimated. E Net exporter.
[1]Defined as mill sales + imports – exports. Information about industry stocks was unavailable.
[2]Range of ex-works mine and mill unit values for individual natural zeolite operations, based on data reported by U.S. producers and U.S. Geological Survey estimates. Average unit values per metric ton for the past 5 years were an estimated $125 in 2020 and 2021; $167 in 2022; $127 in 2023, and $145 in 2024. Prices vary with the percentage of zeolite present in the product, the chemical and physical properties of the zeolite mineral(s), particle size, surface modification and (or) activation, and end use.
[3]Excludes administration and office staff. Estimates based on data from the Mine Safety and Health Administration.
[4]Defined as imports – exports.
[5]See Appendix C for resource and reserve definitions and information concerning data sources.

ZINC

(Data in thousand metric tons, zinc content, unless otherwise specified)

Domestic Production and Use: The estimated value of zinc mined in 2024 was $2.4 billion. Zinc was mined in five States at six mining operations by five companies. Two smelter facilities, one primary and one secondary, operated by two companies, accounted for most of the commercial-grade zinc metal produced in the United States. Of the total reported zinc consumed, most was used to produce galvanized steel, followed by brass and bronze, zinc-base alloys, and other uses.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production:					
Mine, zinc in concentrates	723	704	763	767	750
Refined zinc[e, 1]	180	220	220	220	220
Imports for consumption:					
Ores and concentrates	3	13	5	18	15
Refined zinc	700	701	762	705	600
Exports:					
Ores and concentrates	546	644	644	641	580
Refined zinc	2	13	8	3	2
Shipments from Government stockpile[2]	—	—	1	NA	NA
Consumption, apparent, refined zinc[3]	878	908	974	921	820
Price, average, cents per pound:					
North American[4]	110.8	145.8	190.2	151.3	144
London Metal Exchange (LME), cash	102.7	136.3	158.1	120.1	126
Stocks, reported producer and consumer, refined zinc, yearend	120	115	134	120	120
Employment, number:					
Mine and mill[5]	2,360	2,480	2,500	2,630	2,500
Smelter, primary	220	220	220	340	340
Net import reliance[6] as a percentage of apparent consumption:					
Ores and concentrates	E	E	E	E	E
Refined zinc	79	76	77	76	73

Recycling: Refined zinc produced in the United States was recovered from secondary materials at both primary and secondary smelters. These secondary materials included galvanizing residues and crude zinc oxide recovered from electric arc furnace dust.

Import Sources (2020–23): Ores and concentrates: Peru, 42%; Turkey, 25%; Canada, 16%; Republic of Korea, 10%; and other, 7%. Refined metal: Canada, 59%; Mexico, 16%; Republic of Korea, 7%; Peru, 7%; and other, 11%. Waste and scrap (gross weight): Canada, 64%; Mexico, 34%; and other, 2%. Combined total (includes gross weight of waste and scrap): Canada, 58%; Mexico, 16%; Republic of Korea, 7%; Peru, 7%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Zinc ores and concentrates, zinc content	2608.00.0030	Free.
Zinc oxide; zinc peroxide	2817.00.0000	Free.
Zinc sulfate	2833.29.4500	1.6% ad valorem.
Unwrought zinc, not alloyed:		
Containing 99.99% or more zinc	7901.11.0000	1.5% ad valorem.
Containing less than 99.99% zinc:		
Casting-grade	7901.12.1000	3% ad valorem.
Other	7901.12.5000	1.5% ad valorem.
Zinc alloys	7901.20.0000	3% ad valorem.
Zinc waste and scrap	7902.00.0000	Free.

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile:[7]

	FY 2024		FY 2025	
Material	Potential acquisitions	Potential disposals	Potential acquisitions	Potential disposals
Zinc	—	2.27	—	2.27

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ZINC

Events, Trends, and Issues: U.S. zinc mine production was estimated to have decreased slightly in 2024 compared with that in 2023. There was no production at the Middle Tennessee zinc mines after operations were suspended in November 2023. During the closure, drilling work was conducted to define additional zinc, germanium, and gallium resources. Domestic refined production was estimated to have remained unchanged in 2024 compared with that in the previous year, and apparent consumption decreased alongside an estimated 15% decrease in net imports of refined zinc. Galvanized steel was the leading use of refined zinc in the United States. In September, the U.S. Department of Commerce initiated antidumping and countervailing investigations on corrosion-resistant steel, including galvanized steel, imported from 10 trading partners. In October, the U.S. International Trade Commission preliminarily determined that U.S. industry was materially injured by these imports. Final determinations were expected to be made in 2025.

The annual average LME cash price for Special High Grade (SHG) zinc was projected to decrease by 5% in 2024 from that in 2023. The monthly average North American premium to the LME cash price continued to decrease during 2024 as in 2023 but remained high compared with historical levels. According to the International Lead and Zinc Study Group,[8] estimated global refined zinc production in 2024 was forecast to decrease by 1.8% to 13.7 million tons owing to a limited availability of concentrates, and estimated metal consumption was forecast to increase by 1.8% to 13.8 million tons, resulting in a production-to-consumption deficit of 164,000 tons.

World Mine Production and Reserves: Reserves for China, India, Kazakhstan, Peru, Russia, South Africa, Sweden, and the United States were revised based on company and Government reports.

	Mine production[9]		Reserves[10]
	2023	2024[e]	
United States	767	750	9,200
Australia	1,090	1,100	[11]64,000
Bolivia	492	510	NA
China	4,060	4,000	46,000
India	[e]854	860	9,800
Kazakhstan	340	370	7,600
Mexico	584	700	14,000
Peru	1,470	1,300	20,000
Russia	[e]300	310	29,000
South Africa	198	120	5,900
Sweden	218	240	3,900
Other countries	1,690	1,700	25,000
World total (rounded)	12,100	12,000	230,000

World Resources:[10] Identified zinc resources of the world are about 1.9 billion tons.

Substitutes: Aluminum and plastics substitute for galvanized sheet in automobiles; aluminum alloys, cadmium, paint, and plastic coatings replace zinc coatings in other applications. Aluminum- and magnesium-base alloys are major substitutes for zinc-base diecasting alloys. Many elements are substitutes for zinc in chemical, electronic, and pigment uses.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Includes primary and secondary zinc metal production.
[2]Defined as changes in total inventory from prior yearend inventory. If negative, increase in inventory. Beginning in 2023, Government stock changes no longer available.
[3]Defined for 2020–22 as refined production + refined imports – refined exports ± adjustments for Government stock changes. Beginning in 2023, Government stock changes no longer included.
[4]Source: S&P Global Platts Metals Week, North American SHG zinc; based on the LME cash price plus premium.
[5]Includes mine and mill employment at zinc-containing deposits. Excludes office workers. Source: Mine Safety and Health Administration.
[6]Defined for 2020–22 as imports – exports ± adjustments for Government stock changes. Beginning in 2023, Government stock changes no longer included.
[7]See Appendix B for definitions.
[8]Source: International Lead and Zinc Study Group, 2024, ILZSG session/forecasts: Lisbon, Portugal, International Lead and Zinc Study Group press release, September 30, [4] p.
[9]Zinc content of concentrates and direct shipping ores.
[10]See Appendix C for resource and reserve definitions and information concerning data sources.
[11]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 21 million tons.

ZIRCONIUM AND HAFNIUM

(Data in metric tons unless otherwise specified)

Domestic Production and Use: In 2024, one company recovered zircon (zirconium silicate) from surface-mining operations in Florida and Georgia as a coproduct from the mining of heavy-mineral sands, and a second company processed existing mineral sands tailings in California. Abrasive sands, monazite, and titanium mineral concentrates were coproducts of domestic heavy-mineral-sand operations. Zirconium metal and hafnium metal were produced from zirconium chemical intermediates by one producer in Oregon and one in Utah. Zirconium and hafnium are typically contained in zircon at a ratio of about 50 to 1. Zirconium chemicals were produced from domestic and imported materials by the metal producer in Oregon and by at least 10 other companies. Ceramics, foundry sand, opacifiers, and refractories were the leading end uses for zircon, and other end uses included abrasives, chemicals, metal alloys, and welding rod coatings. The leading consumers of zirconium metal are the chemical process and nuclear energy industries. The leading use of hafnium metal is in superalloys.

Salient Statistics—United States:	2020	2021	2022	2023	2024[e]
Production, zirconium ores and concentrates [zirconium oxide (ZrO_2) content]	<100,000	<100,000	<100,000	<100,000	<100,000
Imports:					
Zirconium ores and concentrates (ZrO_2 content)[1]	15,600	18,500	31,900	20,400	19,000
Zirconium, unwrought, powder, and waste and scrap	2,030	746	346	451	580
Zirconium, wrought	302	265	286	314	340
Hafnium, unwrought, including powders	16	23	43	70	50
Hafnium, wrought	NA	NA	2	6	10
Exports:					
Zirconium ores and concentrates (ZrO_2 content)[1, 2]	12,200	10,000	11,200	13,200	16,000
Zirconium, unwrought, powder, and waste and scrap	664	589	1,090	1,090	1,200
Zirconium, wrought	838	966	805	706	750
Hafnium, unwrought, including powders	--	--	15	58	10
Hafnium, wrought	NA	NA	3	3	5
Consumption, apparent,[3] zirconium ores and concentrates (ZrO_2 content)[1]	<100,000	<100,000	<100,000	<100,000	<100,000
Price:					
Zircon, dollars per metric ton (gross weight):					
Premium grade, cost, insurance, and freight, China[4]	1,490	1,580	2,170	2,160	2,000
Imported[5]	1,400	1,450	2,130	1,980	2,100
Zirconium, sponge, ex-works China,[6] dollars per kilogram	25	25	30	28	25
Hafnium, unwrought,[6] dollars per kilogram	778	781	1,590	6,150	4,600
Net import reliance[7] as a percentage of apparent consumption:					
Zirconium ores and concentrates	<25	<25	<50	<25	<25
Hafnium	NA	NA	NA	NA	NA

Recycling: Companies in Oregon and Utah recycled zirconium from new scrap generated during metal production and fabrication and (or) from post-commercial old scrap. Zircon foundry mold cores and spent or rejected zirconia refractories are often recycled but could not be quantified. Hafnium metal recycling was limited.

Import Sources (2020–23): Zirconium ores and concentrates: South Africa, 46%; Australia, 35%; Senegal, 16%; and other, 3%. Zirconium, unwrought, including powder: China, 88%; Germany, 7%; and other, 5%. Zirconium, wrought: France, 46%; Germany, 19%; Canada, 16%; Belgium, 5%; and other, 14%. Hafnium, unwrought: Germany, 50%; China, 21%; France, 18%; United Kingdom, 5%; and other, 6%.

Tariff: Item	Number	Normal Trade Relations 12–31–24
Zirconium ores and concentrates	2615.10.0000	Free.
Ferrozirconium	7202.99.1000	4.2% ad valorem.
Zirconium, unwrought and powder	8109.21.0000, 8109.29.0000	4.2% ad valorem.
Zirconium waste and scrap	8109.31.0000, 8109.39.0000	Free.
Other zirconium articles	8109.91.0000, 8109.99.0000	3.7% ad valorem.
Hafnium, unwrought, including powders	8112.31.0000	Free.
Hafnium, other	8112.39.0000	4% ad valorem.

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ZIRCONIUM AND HAFNIUM

Depletion Allowance: 22% (domestic), 14% (foreign).

Government Stockpile:[8] Fiscal year 2025 potential acquisitions include 2,300 tons of zirconium.

Events, Trends, and Issues: Global mine production of zirconium mineral concentrates increased by 4% to an estimated 1.5 million tons gross weight in 2024. Several companies continued exploration and development projects with planned production of zirconium mineral concentrates in Australia, Mozambique, South Africa, Sri Lanka, Tanzania, and elsewhere. The leading global exporters of zirconium mineral concentrates were Australia and South Africa. China was the leading importer of zirconium mineral concentrates; China's imports included zircon in mixed and separated heavy-mineral concentrates. U.S. imports of zirconium mineral concentrates continued to decrease in 2024, whereas exports increased. Australia, Senegal, and South Africa were still the leading import sources of zirconium mineral concentrates. The United States was a net exporter of zirconium metal. U.S. exports of unwrought hafnium decreased by almost 80% in 2024 after a nearly fourfold increase in 2023, and imports decreased by almost 30%. The leading global exporters of unwrought hafnium were China, Germany, and the Netherlands.

World Mine Production and Reserves: World primary hafnium production data and quantitative estimates of hafnium reserves were not available. Zirconium reserves for Australia, Kenya, Madagascar, and South Africa were revised based on company and Government reports.

	Zirconium mineral concentrates, mine production[e] (thousand metric tons, gross weight)		Zirconium reserves[9] (thousand metric tons, ZrO_2 content)[1]
	2023	2024	
United States	[10]100	[10]100	500
Australia	500	500	[11]55,000
China	100	100	72
Indonesia	95	95	NA
Kenya	[12]20	20	5
Madagascar	34	30	2,100
Mozambique	[12]144	160	1,500
Senegal	[12]48	60	2,600
Sierra Leone	[12]28	20	290
South Africa	[12]289	300	5,300
Other countries	86	110	5,700
World total (rounded)	1,440	1,500	>70,000

World Resources:[8] Resources of zircon in the United States included about 14 million tons associated with titanium resources in heavy-mineral-sand deposits. Phosphate rock and sand and gravel deposits could potentially yield substantial amounts of zircon as a byproduct. World resources of hafnium are associated with those of zircon and baddeleyite. Quantitative estimates of hafnium resources were not available.

Substitutes: Chromite and olivine can be used instead of zircon for some foundry applications. Dolomite and spinel refractories can also substitute for zircon in certain high-temperature applications. Niobium (columbium), stainless steel, and tantalum provide limited substitution in nuclear applications, and titanium and synthetic materials may substitute in some chemical processing plant applications. Boron or cadmium-silver-indium alloys are sometimes used in lieu of hafnium metal in control rods at nuclear powerplants. Zirconium can be used interchangeably with hafnium in certain superalloys.

[e]Estimated. E Net exporter. NA Not available.
[1]Calculated ZrO_2 content as 65% of gross weight.
[2]Excludes zircon in mixed mineral concentrates.
[3]Defined as production + imports – exports.
[4]Source: Fastmarkets IM.
[5]Unit value based on landed-duty-paid United States imports for consumption from Australia, Senegal, and South Africa.
[6]Source: Argus Media Group, Argus Non-Ferrous Markets, annual average.
[7]Defined as imports – exports.
[8]See Appendix B for definitions.
[9]See Appendix C for resource and reserve definitions and information concerning data sources.
[10]Data are rounded to the nearest hundred thousand tons to avoid disclosing company proprietary data.
[11]For Australia, Joint Ore Reserves Committee-compliant or equivalent reserves were 20 million tons, ZrO_2 content.
[12]Reported.

APPENDIX A

Abbreviations and Units of Measure

1 carat (metric) (diamond)	= 200 milligrams
1 flask (fl)	= 76 pounds, avoirdupois, or 34.47 kilograms
1 karat (gold)	= one twenty-fourth part
1 kilogram (kg)	= 2.2046 pounds, avoirdupois
1 long ton (lt)	= 2,240 pounds, avoirdupois
1 long ton unit (ltu)	= 1% of 1 long ton, or 22.4 pounds, avoirdupois
long calcined ton (lct)	= excludes water of hydration
long dry ton (ldt)	= excludes excess free moisture
Mcf	= 1,000 cubic feet
1 metric ton (t)	= 2,204.6 pounds, avoirdupois, or 1,000 kilograms
1 metric ton (t)	= 1.1023 short ton
1 metric ton unit (mtu)	= 1% of 1 metric ton, or 10 kilograms
metric dry ton (mdt)	= excludes excess free moisture
1 pound (lb)	= 453.6 grams
psia	= pounds per square inch absolute
1 short ton (st)	= 2,000 pounds, avoirdupois
1 short ton unit (stu)	= 1% of 1 short ton, or 20 pounds, avoirdupois
short dry ton (sdt)	= excludes excess free moisture
1 troy ounce (tr oz)	= 1.09714 avoirdupois ounces, or 31.103 grams
1 troy pound	= 12 troy ounces

APPENDIX B

Definitions of Selected Terms Used in This Report

Terms Used for Materials in the National Defense Stockpile and Federal Helium Reserve

Fiscal year for the U.S. Government is the period from October 1 through September 30. Fiscal year (FY) 2024 is from October 1, 2023, through September 30, 2024. FY 2025 is from October 1, 2024, through September 30, 2025.

Inventory refers to the quantity of mineral materials held in the National Defense Stockpile or in the Federal Helium Reserve. Beginning in 2023, National Defense Stockpile shipments and inventory levels are no longer included.

Potential disposals indicate the total amount of a material in the National Defense Stockpile that the U.S. Department of Defense is permitted to dispose of under the Annual Materials Plan approved by Congress for the fiscal year. Congress has authorized disposal over the long term at rates designed to maximize revenue but avoid undue disruption to the usual markets and financial loss to the United States. Disposals are defined as any disposal or sale of National Defense Stockpile stock. The Federal Helium System assets (formerly operated by the Bureau of Land Management) were sold and transferred in June 2024 to a private company. This satisfied the requirements of the Helium Stewardship Act of 2013 (HSA), which mandated the privatization of the Federal Helium System.

Potential acquisitions indicate the maximum amount of a material that may be acquired by the U.S. Department of Defense for the National Defense Stockpile under the Annual Materials Plan approved by Congress for the fiscal year.

Depletion Allowance

The depletion allowance is a business tax deduction analogous to depreciation, but which applies to an ore reserve rather than equipment or production facilities. Federal tax law allows this deduction from taxable corporate income, recognizing that an ore deposit is a depletable asset that must eventually be replaced.

APPENDIX C

Reserves and Resources

Reserves data are dynamic. They may be reduced as ore is mined and (or) the feasibility of extraction diminishes, or more commonly, they may continue to increase as additional deposits (known or recently discovered) are developed, or currently exploited deposits are more thoroughly explored and (or) new technology or economic variables improve their economic feasibility. Reserves may be considered a working inventory of mining companies' supplies of an economically extractable mineral commodity. As such, the magnitude of that inventory is necessarily limited by many considerations, including cost of drilling, taxes, price of the mineral commodity being mined, and the demand for it. Reserves will be developed to the point of business needs and geologic limitations of economic ore grade and tonnage. For example, in 1970, identified and undiscovered world copper resources were estimated to contain 1.6 billion metric tons of copper, with reserves of about 280 million tons of copper. Since then, about 697 million tons of copper have been produced worldwide, but world copper reserves in 2024 were estimated to be 980 million tons of copper, more than 3.5 times those in 1970, despite the depletion by mining of much more than the 1970 estimated reserves.

Future supplies of minerals will come from reserves and other identified resources, currently undiscovered resources in deposits that will be discovered in the future, and material that will be recycled from current in-use stocks of minerals or from minerals in waste disposal sites. Undiscovered deposits of minerals constitute an important consideration in assessing future supplies. Mineral-resource assessments have been carried out for small parcels of land being evaluated for land reclassification, for the Nation, and for the world.

Part A—Resource and Reserve Classification for Minerals[1]

Introduction

Through the years, geologists, mining engineers, and others operating in the minerals field have used various terms to describe and classify mineral resources, which as defined herein include energy materials. Some of these terms have gained wide use and acceptance, although they are not always used with precisely the same meaning.

The U.S. Geological Survey (USGS) collects information about the quantity and quality of all mineral resources. In 1976, the USGS and the U.S. Bureau of Mines developed a common classification and nomenclature, which was published as USGS Bulletin 1450–A—"Principles of the Mineral Resource Classification System of the U.S. Bureau of Mines and U.S. Geological Survey." Experience with this resource classification system showed that some changes were necessary in order to make it more workable in practice and more useful in long-term planning. Therefore, representatives of the USGS and the U.S. Bureau of Mines collaborated to revise Bulletin 1450–A. Their work was published in 1980 as USGS Circular 831—"Principles of a Resource/Reserve Classification for Minerals."

Long-term public and commercial planning must be based on the probability of discovering new deposits, on developing economic extraction processes for currently unworkable deposits, and on knowing which resources are immediately available. Thus, resources must be continuously reassessed in the light of new geologic knowledge, of progress in science and technology, and of shifts in economic and political conditions. To best serve these planning needs, known resources should be classified from two standpoints: (1) purely geologic or physical and chemical characteristics—such as grade, quality, tonnage, thickness, and depth—of the material in place; and (2) profitability analyses based on costs of extracting and marketing the material in a given economy at a given time. The former constitutes important objective scientific information of the resource and a relatively unchanging foundation upon which the latter more valuable economic delineation can be based.

The revised classification system, designed generally for all mineral materials, is shown graphically in figures C1 and C2; its components and their usage are described in the text. The classification of mineral and energy resources is necessarily arbitrary because definitional criteria do not always coincide with natural boundaries. The system can be used to report the status of mineral and energy-fuel resources for the Nation or for specific areas.

Resource and Reserve Definitions

A dictionary definition of resource, "something in reserve or ready if needed," has been adapted for mineral and energy resources to comprise all materials, including those only surmised to exist, that have present or anticipated future value.

Resource.—A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

Original Resource.—The amount of a resource before production.

Identified Resources.—Resources for which location, grade, quality, and quantity are known or estimated from specific geologic evidence. Identified resources include economic, marginally economic, and subeconomic components. To reflect varying degrees of geologic certainty, these economic divisions can be subdivided into measured, indicated, and inferred.

[1]Based on U.S. Geological Survey Circular 831, 1980.

Demonstrated.—A term for the sum of measured plus indicated resources.

Measured.—Quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes; grade and (or) quality are computed from the results of detailed sampling. The sites for inspection, sampling, and measurements are spaced so closely and the geologic character is so well defined that size, shape, depth, and mineral content of the resource are well established.

Indicated.—Quantity and grade and (or) quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurements are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough to assume continuity between points of observation.

Inferred.—Estimates are based on an assumed continuity beyond measured and (or) indicated resources, for which there is geologic evidence. Inferred resources may or may not be supported by samples or measurements.

Reserve Base.—That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth. The reserve base is the in-place demonstrated (measured plus indicated) resource from which reserves are estimated. It may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. The reserve base includes those resources that are currently economic (reserves), marginally economic (marginal reserves), and some of those that are currently subeconomic (subeconomic resources). The term “geologic reserve” has been applied by others generally to the reserve-base category, but it also may include the inferred-reserve-base category; it is not a part of this classification system.

Inferred Reserve Base.—The in-place part of an identified resource from which inferred reserves are estimated. Quantitative estimates are based largely on knowledge of the geologic character of a deposit and for which there may be no samples or measurements. The estimates are based on an assumed continuity beyond the reserve base, for which there is geologic evidence.

Reserves.—That part of the reserve base that could be economically extracted or produced at the time of determination. The term “reserves” need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as “extractable reserves” and “recoverable reserves” are redundant and are not a part of this classification system.

Marginal Reserves.—That part of the reserve base which, at the time of determination, borders on being economically producible. Its essential characteristic is economic uncertainty. Included are resources that would be producible, given postulated changes in economic or technological factors.

Economic.—This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

Subeconomic Resources.—The part of identified resources that does not meet the economic criteria of reserves and marginal reserves.

Undiscovered Resources.—Resources, the existence of which are only postulated, comprising deposits that are separate from identified resources. Undiscovered resources may be postulated in deposits of such grade and physical location as to render them economic, marginally economic, or subeconomic. To reflect varying degrees of geologic certainty, undiscovered resources may be divided into two parts, as follows:

Hypothetical Resources.—Undiscovered resources that are similar to known mineral bodies and that may be reasonably expected to exist in the same producing district or region under analogous geologic conditions. If exploration confirms their existence and reveals enough information about their quality, grade, and quantity, they will be reclassified as identified resources.

Speculative Resources.—Undiscovered resources that may occur either in known types of deposits in favorable geologic settings where mineral discoveries have not been made, or in types of deposits as yet unrecognized for their economic potential. If exploration confirms their existence and reveals enough information about their quantity, grade, and quality, they will be reclassified as identified resources.

Restricted Resources or Reserves.—That part of any resource or reserve category that is restricted from extraction by laws or regulations. For example, restricted reserves meet all the requirements of reserves except that they are restricted from extraction by laws or regulations.

Other Occurrences.—Materials that are too low grade or for other reasons are not considered potentially economic, in the same sense as the defined resource, may be recognized and their magnitude estimated, but they are not classified as resources. A separate category, labeled “other occurrences,” is included in figures C1 and C2. In figure C1, the boundary between subeconomic and other occurrences is limited by the concept of current or potential feasibility of economic production, which is required by the definition of a resource. The boundary is obviously uncertain, but limits may be specified in terms of grade, quality, thickness, depth, extractable percentage, or other economic-feasibility variables.

Cumulative Production.—The amount of past cumulative production is not, by definition, a part of the resource. Nevertheless, a knowledge of what has been produced is important in order to understand current resources, in terms of both the amount of past production and the amount of residual or remaining in-place resource. A separate space for cumulative production is shown in figures C1 and C2. Residual material left in the ground during current or future extraction should be recorded in the resource category appropriate to its economic-recovery potential.

Figure C1.—Major Elements of Mineral-Resource Classification, Excluding *Reserve Base* and *Inferred Reserve Base*

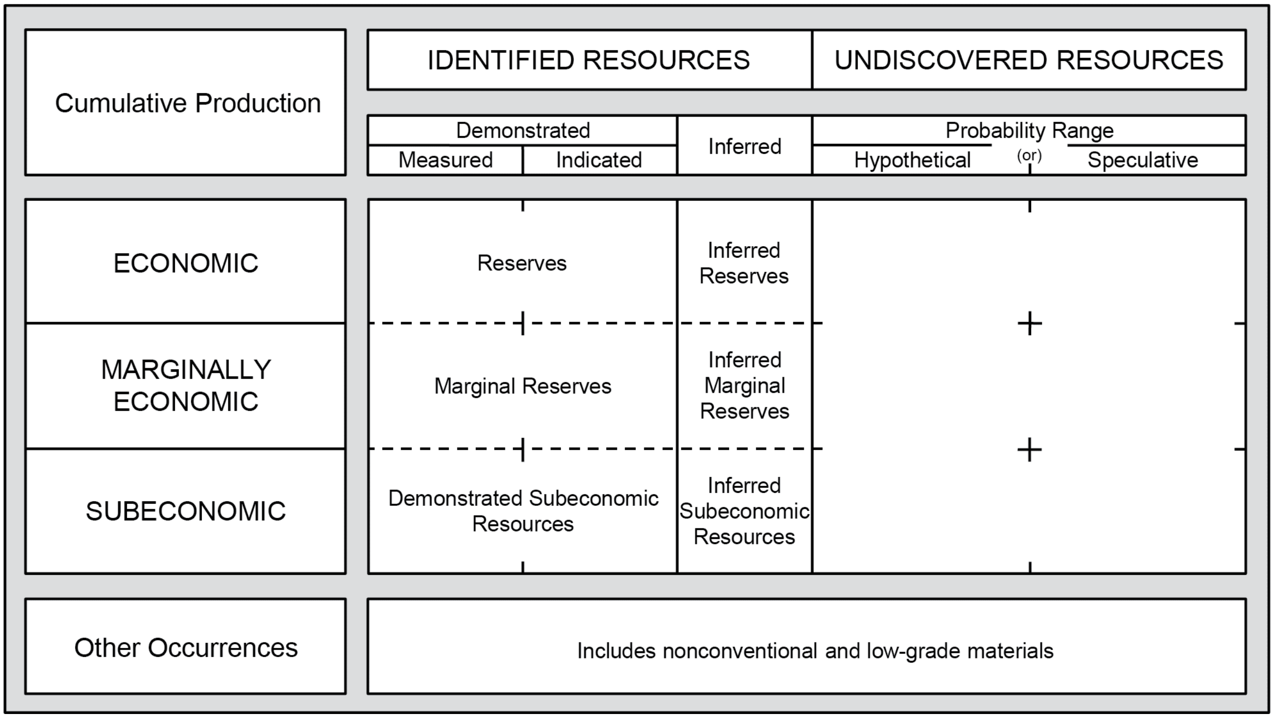
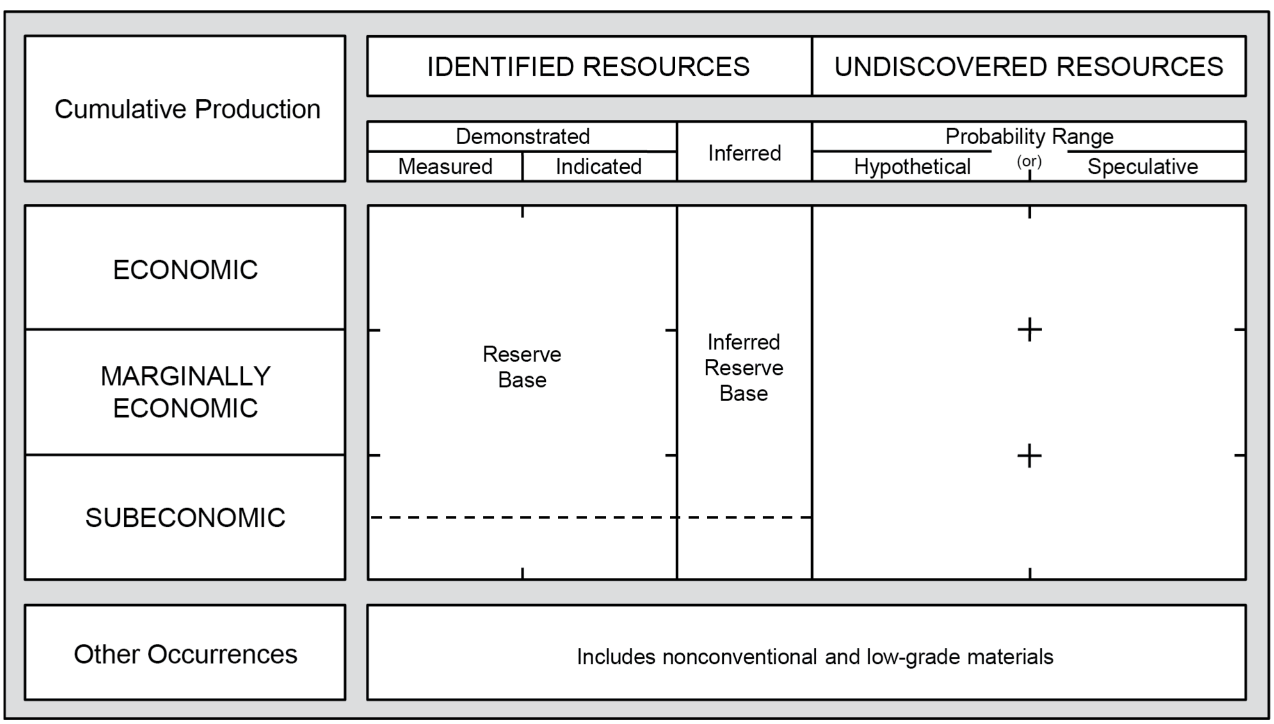


Figure C2.—*Reserve Base* and *Inferred Reserve Base* Classification Categories



Part B—Sources of Reserves Data

National information on reserves for most mineral commodities found in this report, including those for the United States, is derived from a variety of sources. The ideal source of such information would be comprehensive evaluations that apply the same criteria to deposits in different geographic areas and report the results by country. In the absence of such evaluations, national reserves estimates compiled by countries for selected mineral commodities are a primary source of national reserves information. Lacking national assessment information by governments, sources such as academic articles, company reports, presentations by company representatives, and trade journal articles, or a combination of these, serve as the basis for national information on reserves reported in the mineral commodity sections of this publication.

A national estimate may be assembled from the following: historically reported reserves information carried for years without alteration because no new information is available, historically reported reserves reduced by the amount of historical production, and company-reported reserves. International minerals availability studies conducted by the U.S. Bureau of Mines before 1996 and estimates of identified resources by an international collaborative effort (the International Strategic Minerals Inventory) are the bases for some reserves estimates. The USGS collects some qualitative information about the quantity and quality of mineral resources but does not directly measure reserves or resources, and companies or governments do not directly report information about reserves or resources to the USGS. Reassessment of reserves is a continuing process, and the intensity of this process differs by mineral commodity, country, and time period.

Some countries have specific definitions for reserves data, and reserves for each country are assessed separately, based on reported data and definitions. An attempt is made to make reserves consistent among countries for a mineral commodity and its byproducts. For example, the Australasian Joint Ore Reserves Committee (JORC) established the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC Code) that sets out minimum standards, recommendations, and guidelines for public reporting in Australasia of exploration results, mineral resources, and ore reserves. Companies listed on the Australian Securities Exchange and the New Zealand Stock Exchange are required to report publicly on ore reserves and mineral resources under their control, using the JORC Code.

Data reported for individual deposits by mining companies are compiled in Geoscience Australia's national mineral resources database and used in the preparation of the annual national assessments of Australia's mineral resources. Because of its specific use in the JORC Code, the term "reserves" is not used in the national inventory, where the highest category is "Economic Demonstrated Resources" (EDR). In essence, EDR combines the JORC Code categories "proved reserves" and "probable reserves," plus measured resources and indicated resources. This is considered to provide a reasonable and objective estimate of what is likely to be available for mining in the long term. Accessible Economic Demonstrated Resources represent the resources within the EDR category that are accessible for mining. Reserves for Australia in the Mineral Commodity Summaries 2025 are Accessible EDR. For more information, see "Australia's Estimated Ore Reserves as at December 2022—Table 2" (https://www.ga.gov.au/aimr2023/australias-estimated-ore-reserves).

In Canada, the Canadian Institute of Mining, Metallurgy and Petroleum (CIM) provides definition standards for the classification of mineral resources and mineral reserves estimates into various categories. The category to which a resource or reserves estimate is assigned depends on the level of confidence in the geologic information available on the mineral deposit, the quality and quantity of data available on the deposit, the level of detail of the technical and economic information that has been generated about the deposit, and the interpretation of the data and information. For more information on the CIM definition standards, see https://mrmr.cim.org/media/1128/cim-definition-standards_2014.pdf.

In Russia, reserves for most minerals can appear in a number of sources, although no comprehensive list of reserves is published. Reserves data for a limited set of mineral commodities are available in the annual report "Gosudarstvennyi Doklad o Sostoyanii i Ispol'zovanii Mineral'no-Syryevyh Resursov Rossiyskoy Federatsii" (State Report on the State and Use of Mineral and Raw Materials Resources of the Russian Federation), which is published by Russia's Ministry of Natural Resources and Environment. Reserves data for various minerals appear at times in journal articles, such as those in the journal "Mineral'nyye Resursy Rossii. Ekonomika i Upravleniye" (Mineral Resources of Russia. Economics and Management), which is published by the "OOO RG-Inform," a subsidiary of Rosgeologiya Holding. Also, reserves data for individual jurisdictions are available on the website of the Federal'noye Agenstvo po Nedropol'zovaniyu (Federal Agency for Subsoil Use). It is sometimes not clear if the reserves are being reported in ore or mineral content. It is also in many cases not clear which definition of reserves is being used, because the system inherited from the former Soviet Union has a number of ways in which the term "reserves" is defined, and these definitions qualify the percentage of resources that are included in a specific category. For example, the Soviet reserves classification system, besides the categories A, B, C1, and C2, which represent progressively detailed knowledge of a mineral deposit based on exploration data, has other subcategories cross imposed upon the system. Under the broad category reserves (zapasy), there are subcategories that include balance reserves (balansovyye zapasy, or economic reserves) and outside-the-balance reserves (zabalansovye zapasy, or subeconomic reserves), as well as categories that include explored, industrial, and proven reserves, and the reserves totals can vary significantly, depending on the specific definition of reserves being reported.

APPENDIX D

Country Specialists Directory

Minerals information country specialists at the U.S. Geological Survey collect and analyze information on the mineral industries of more than 170 nations throughout the world. The specialists are available to answer minerals-related questions concerning individual countries.

Africa and the Middle East

Algeria	Mowafa Taib
Angola	Meralis Plaza-Toledo
Bahrain	Iman Salehi Hikouei
Benin	Meralis Plaza-Toledo
Botswana	Thomas R. Yager
Burkina Faso	Alberto Alexander Perez
Burundi	Thomas R. Yager
Cabo Verde	Meralis Plaza-Toledo
Cameroon	Edgardo J. Pujols
Central African Republic	Edgardo J. Pujols
Chad	Edgardo J. Pujols
Comoros	Edgardo J. Pujols
Congo (Brazzaville)	Edgardo J. Pujols
Congo (Kinshasa)	Thomas R. Yager
Côte d'Ivoire	Alberto Alexander Perez
Djibouti	Thomas R. Yager
Egypt	Mowafa Taib
Equatorial Guinea	Meralis Plaza-Toledo
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Ghana	Meralis Plaza-Toledo
Guinea	Alberto Alexander Perez
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Iran	Iman Salehi Hikouei
Iraq	Iman Salehi Hikouei
Israel	Iman Salehi Hikouei
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Madagascar	Thomas R. Yager
Malawi	Thomas R. Yager
Mali	Alberto Alexander Perez
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Mauritius	Edgardo J. Pujols
Morocco and Western Sahara	Mowafa Taib
Mozambique	Meralis Plaza-Toledo
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Niger	Alberto Alexander Perez
Nigeria	Thomas R. Yager
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Sudan	Alberto Alexander Perez
Syria	Mowafa Taib
Tanzania	Thomas R. Yager
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Tunisia	Mowafa Taib
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