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

MINERAL COMMODITY SUMMARIES 2018

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 Crystal
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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Cover: A conveyor transports crushed stone from a quarry to a stockpile at an operation in Virginia. Crushed stone is used in road base, as a construction aggregate, and for other materials needed for infrastructure development and improvement. (Photograph by Michael T. Jarvis, outreach coordinator, and design by Graham W. Lederer, materials flow analyst, U.S. Geological Survey, National Minerals Information Center)

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Gold
Graphite
Gypsum
Hafnium
Helium
Indium
Iodine
Iron and Steel
Iron Ore
Iron Oxide Pigments
Kyanite
Lead
Lime
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Manganese
Mercury
Mica
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Nickel
Niobium
Nitrogen
Palladium
Peat
Perlite
Phosphate Rock
Platinum
Potash
Pumice
Quartz Crystal
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

USGS
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exercising the authority of the Director

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INSTANT INFORMATION

Information about the U.S. Geological Survey, its programs, staff, and products is available from the internet at <https://www.usgs.gov> or by calling (888) ASK–USGS [(888) 275–8747].

This publication has been prepared by the National Minerals Information Center. Information about the Center and its products is available from the internet at <https://minerals.usgs.gov/minerals> or by writing to Director, National Minerals Information Center, 988 National Center, Reston, VA 20192.

KEY PUBLICATIONS

Minerals Yearbook—These annual publications review the mineral industries of the United States and of more than 180 other countries. They contain statistical data on minerals and materials and include information on economic and technical trends and developments and are available at <https://minerals.usgs.gov/minerals/pubs/myb.html>. 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://minerals.usgs.gov/minerals/pubs/mcs/>. Data sheets contain information on the domestic industry structure, Government programs, tariffs, 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://minerals.usgs.gov/minerals/pubs/commodity/mis.html>. The surveys are issued monthly, quarterly, or at other regular intervals.

Metal Industry Indicators—This monthly publication analyzes and forecasts the economic health of three metal industries (primary metals, steel, and copper) using leading and coincident indexes and is available at <https://minerals.usgs.gov/minerals/pubs/mii/>.

Nonmetallic Mineral Products Industry Indexes—This monthly publication analyzes the leading and coincident indexes for the nonmetallic mineral products industry (NAICS 327) and is available at <https://minerals.usgs.gov/minerals/pubs/imii/>.

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://minerals.usgs.gov/minerals/mflow/>.

Recycling Reports—These studies illustrate the recycling of metal commodities and identify recycling trends and are available at <https://minerals.usgs.gov/minerals/pubs/commodity/recycle/>.

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://minerals.usgs.gov/minerals/pubs/historical-statistics/>.

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 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 in PDF format (and some are available in XLS format) through <https://minerals.usgs.gov/minerals>.

INTRODUCTION

Each chapter of the 2018 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 and resources. The MCS is the earliest comprehensive source of 2017 mineral production data for the world. More than 90 individual minerals and materials are covered by two-page synopses.

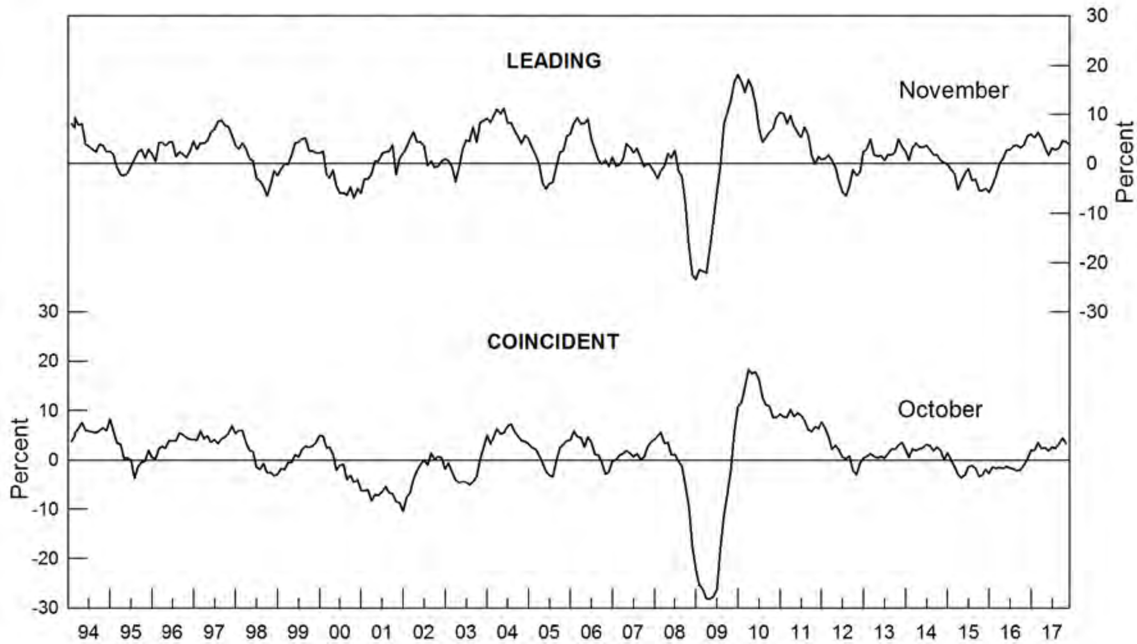
For mineral commodities for which there is a Government stockpile, detailed information concerning the stockpile status is included in the two-page synopsis.

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

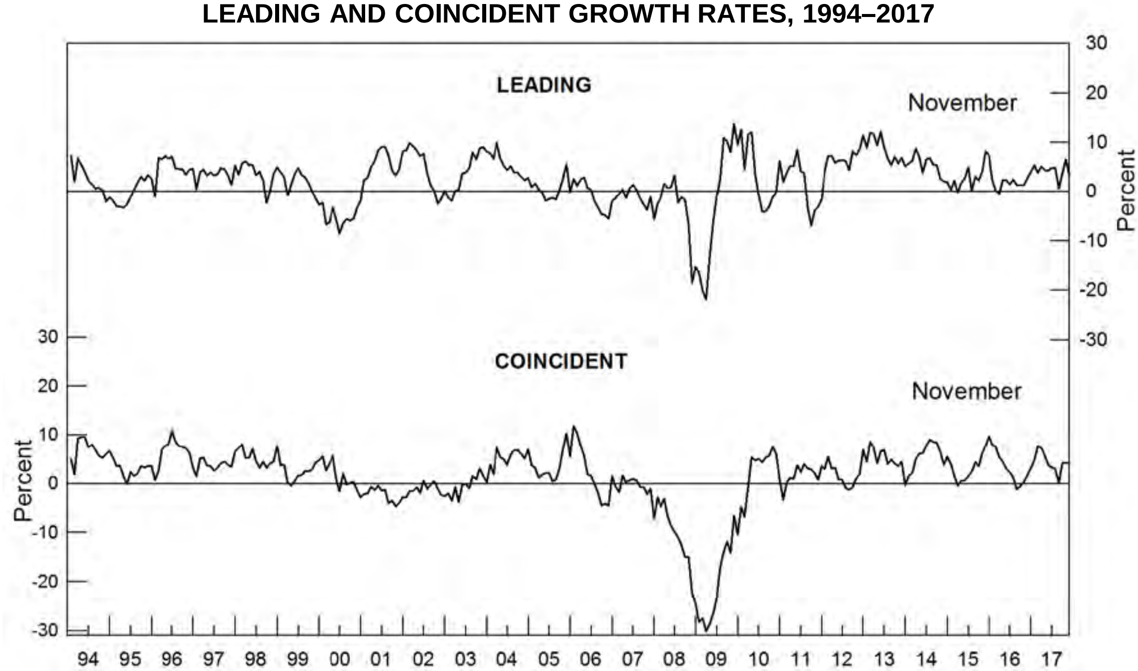
The USGS continually strives to improve the value of its publications to users. Constructive comments and suggestions by readers of the MCS 2018 are welcomed.

GROWTH RATES OF LEADING AND COINCIDENT INDEXES FOR MINERAL PRODUCTS

PRIMARY METALS: LEADING AND COINCIDENT GROWTH RATES, 1994–2017



NONMETALLIC MINERAL PRODUCTS: LEADING AND COINCIDENT GROWTH RATES, 1994–2017

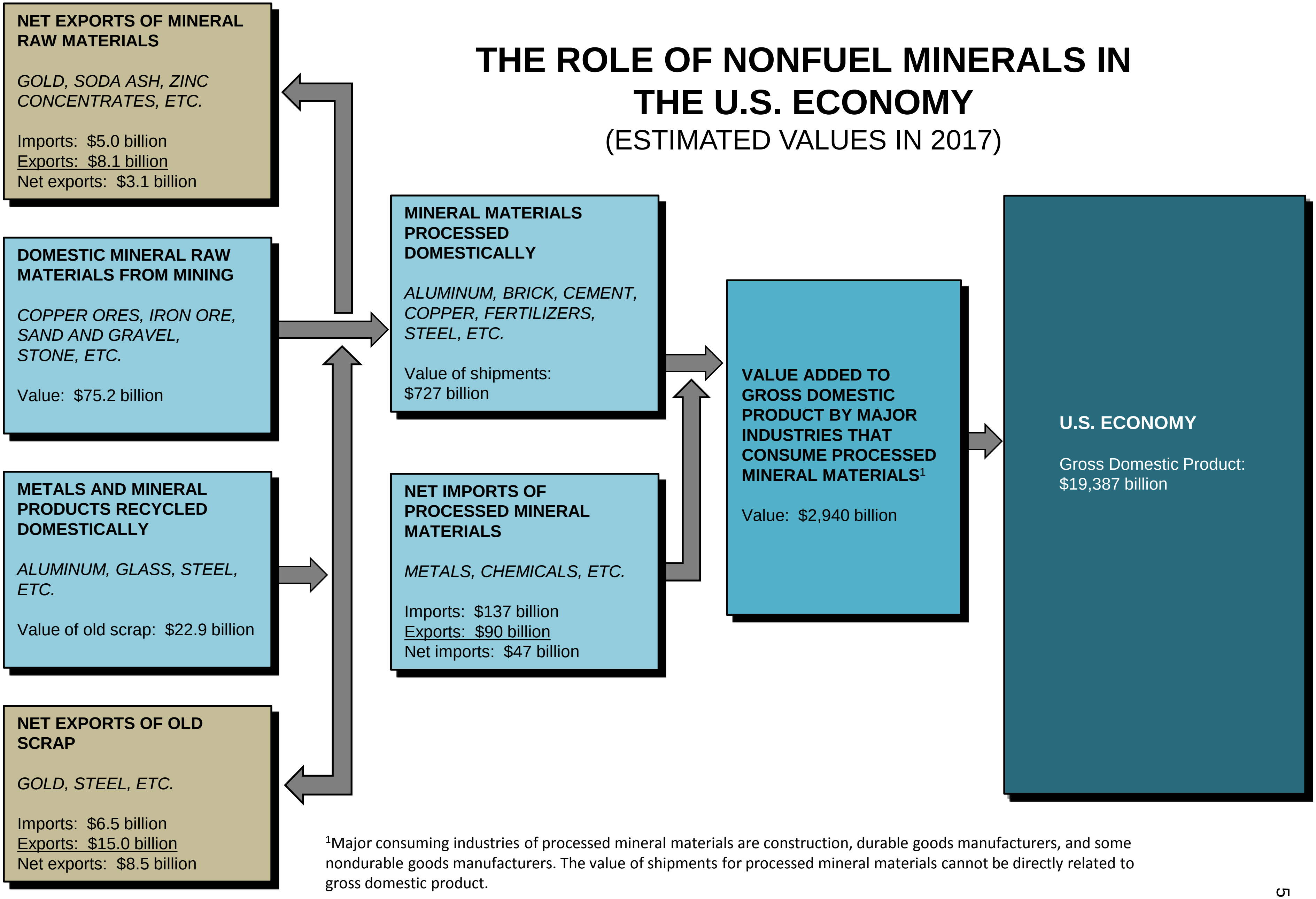


The leading indexes historically give signals several months in advance of major changes in the corresponding coincident index, which measures current industry activity. The growth rates, which can be viewed as trends, are expressed as compound annual rates based on the ratio of the current month's index to its average level during the preceding 12 months.

Sources: U.S. Geological Survey, *Metal Industry Indicators* and *Nonmetallic Mineral Products Industry Indexes.*

THE ROLE OF NONFUEL MINERALS IN THE U.S. ECONOMY

(ESTIMATED VALUES IN 2017)



[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 the U.S. Department of Commerce

2017 U.S. NET IMPORT RELIANCE[1]

Commodity	Percent	Major import sources (2013–16)[2]
ARSENIC (trioxide)	100	Morocco, China, Belgium
ASBESTOS	100	Brazil, Russia
CESIUM	100	Canada
FLUORSPAR	100	Mexico, China, South Africa, Vietnam
GALLIUM	100	China, Germany, United Kingdom, Ukraine
GRAPHITE (natural)	100	China, Mexico, Canada, Brazil
INDIUM	100	Canada, China, France, Republic of Korea
MANGANESE	100	South Africa, Gabon, Australia, Georgia
MICA, sheet (natural)	100	China, Brazil, Belgium, Austria
NEPHELINE SYENITE	100	Canada
NIOBIUM (columbium)	100	Brazil, Canada, Russia
QUARTZ CRYSTAL (industrial)	100	China, Japan, Romania, United Kingdom
RARE EARTHS	100	China, Estonia, France, Japan
RUBIDIUM	100	Canada
SCANDIUM	100	China
STRONTIUM	100	Mexico, Germany, China
TANTALUM	100	Brazil, Rwanda, Australia, Canada
THALLIUM	100	Russia, Germany
THORIUM	100	India, United Kingdom
VANADIUM	100	Czechia, Austria, Canada, Republic of Korea
YTTRIUM	100	China, Estonia, Japan, Germany
GEMSTONES	99	Israel, India, Belgium, South Africa
BISMUTH	96	China, Belgium, Peru
POTASH	92	Canada, Russia, Israel, Chile
TITANIUM MINERAL CONCENTRATES	91	South Africa, Australia, Canada, Mozambique
ANTIMONY (oxide)	85	China, Belgium, Bolivia
ZINC	85	Canada, Mexico, Peru, Australia
STONE, dimension	83	China, Brazil, Italy, Turkey
RHENIUM	80	Chile, Belgium, Germany, Poland
ABRASIVES, fused aluminum oxide (crude)	>75	China, Canada, France
ABRASIVES, silicon carbide (crude)	>75	China, Netherlands, South Africa, Romania
BARITE	>75	China, India, Mexico, Morocco
BAUXITE	>75	Jamaica, Brazil, Guinea, Guyana
TELLURIUM	>75	Canada, China, Belgium, Philippines
TIN	75	Peru, Indonesia, Malaysia, Bolivia
COBALT	72	Norway, China, Japan, Finland
PEAT	71	Canada
DIAMOND (dust, grit, and powder)	70	China, Ireland, Russia, Romania
CHROMIUM	69	South Africa, Kazakhstan, Russia
PLATINUM	68	South Africa, Germany, United Kingdom, Russia
SILVER	62	Mexico, Canada, Peru, Poland
ALUMINUM	61	Canada, Russia, United Arab Emirates, China
NICKEL	59	Canada, Norway, Australia, Russia
TITANIUM (sponge)	53	Japan, China, Kazakhstan, Ukraine
GERMANIUM	>50	China, Belgium, Russia, Germany
IODINE	>50	Chile, Japan
IRON OXIDE PIGMENTS (natural)	>50	Cyprus, Spain, France, Austria
IRON OXIDE PIGMENTS (synthetic)	>50	China, Germany, Canada, Brazil
LITHIUM	>50	Chile, Argentina, China
TUNGSTEN	>50	China, Canada, Bolivia, Germany
BROMINE	<50	Israel, China, Jordan
ZIRCONIUM MINERAL CONCENTRATES	<50	South Africa, Australia, Senegal
ZIRCONIUM	<50	China, Germany, Japan
MAGNESIUM COMPOUNDS	47	China, Canada, Australia, Brazil
GARNET (industrial)	46	Australia, India, South Africa, China
PALLADIUM	45	South Africa, Russia, Italy, United Kingdom
MICA, scrap and flake (natural)	42	Canada, China, India, Finland
LEAD	40	Canada, Republic of Korea, Mexico, India
ALUMINA	37	Australia, Suriname, Brazil, Jamaica
SILICON	35	Russia, Brazil, Canada, China
COPPER	33	Chile, Canada, Mexico
VERMICULITE	30	Brazil, South Africa, China, Zimbabwe
PUMICE	27	Greece, Iceland, Mexico
FELDSPAR	26	Turkey, Mexico, Spain

[1]Not all mineral commodities covered in this publication are listed here. Those not shown include mineral commodities for which the United States is a net exporter (abrasives, metallic; boron; clays; diatomite; gold; helium; iron and steel scrap; iron ore; kyanite; molybdenum; sand and gravel, industrial; selenium; soda ash; titanium dioxide pigment; wollastonite; and zeolites) or less than 25% import reliant (beryllium; cadmium; cement; diamond, industrial stones; gypsum; iron and steel; iron and steel slag; lime; magnesium metal; nitrogen (fixed)—ammonia; perlite; phosphate rock; sand and gravel, construction; salt; stone, crushed; sulfur; and talc). For some mineral commodities (hafnium and mercury), not enough information is available to calculate the exact percentage of import reliance.

[2]In descending order of import share.

SIGNIFICANT EVENTS, TRENDS, AND ISSUES

In 2017, the estimated value of total nonfuel mineral production in the United States was $75.2 billion, a 6% increase from the revised total of $70.8 billion in 2016. The estimated value of metals production increased 12% to $26.3 billion. Higher prices contributed to some metal commodity values increasing more than 35% (cobalt, magnesium metal, and palladium). Despite this increase, some U.S. metal mines and processing facilities remained idle in 2017, including three primary aluminum smelters in Indiana, Missouri, and Washington; a titanium sponge facility in Utah; and a byproduct vanadium production facility in Utah. However, new gold mines opened in late 2016 and 2017 in Nevada and South Carolina, respectively, and iron ore mines in Michigan and Minnesota restarted or operated for the full year. The total value of industrial minerals production was $48.9 billion, a 3% increase from that of 2016. Of this total, $23 billion was aggregates production (construction sand and gravel and crushed stone). Increased oil and natural gas drilling activity resulted in increased production of some industrial mineral commodities. Limited growth in construction activity resulted in the production of some industrial minerals, especially those used in infrastructure and residential construction, to remain essentially unchanged in 2017.

The U.S. Geological Survey (USGS) calculates composite leading and coincident indexes to track economic activity in the primary metals and the nonmetallic minerals industries. As shown in the charts on page 4, for each of the indexes, a growth rate is calculated to measure its change relative to the previous 12 months. The indexes' growth rate is a 6-month smoothed compound annual rate, which measures near-term trend. Usually, a growth rate above +1.0% signals an increase in primary metals or nonmetallic minerals industry activity, and a growth rate below -1.0% indicates a downturn in activity. The primary metals leading index growth rate was above +1.0% from January through November 2017 and has been above +1.0% since April 2016, which could indicate strength in primary metals industry activity. The nonmetallic mineral products industry leading index growth rate was above the +1.0% threshold January through July 2017, below in August, and above +1.0% September through November. This may suggest near-term strength in the nonmetallic mineral products industry.

As shown in the figure on page 5, 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 2017 was $75.2 billion. Domestic raw materials and domestically recycled materials were used to produce mineral materials worth $727 billion. These mineral materials were, in turn, consumed by downstream industries with an estimated value of $2.94 trillion in 2017, a 3.5% increase from the revised figure of $2.87 trillion in 2016.

The figure on page 6 illustrates the reliance of the United States on foreign sources for raw and processed mineral materials. In 2017, imports made up more than one-half of the U.S. apparent consumption for 50 nonfuel mineral commodities, and the United States was 100% import reliant for 21 of those. The figure on page 8 shows the countries from which the majority of these mineral commodities were imported and the number of mineral commodities for which each highlighted country was a leading supplier. China, followed by Canada, supplied the largest number of nonfuel mineral commodities. The United States was import reliant for an additional 31 commodities and was a net exporter of 16 nonfuel mineral commodities.

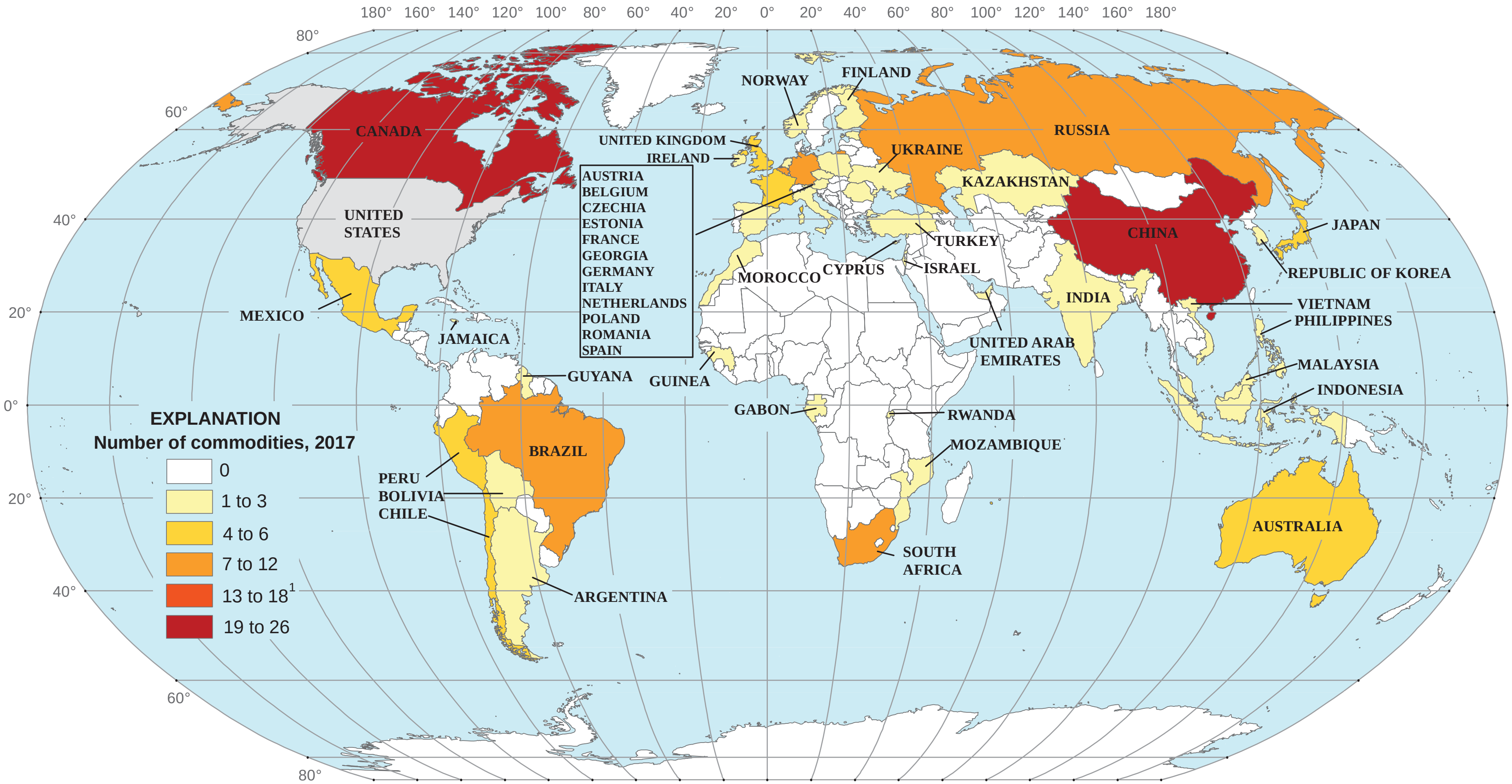
The estimated value of U.S. metal mine production in 2017 was $26.3 billion (table 1), 12% more than that of 2016. Principal contributors to the total value of metal mine production in 2017 were gold (38%), copper (30%), iron ore (12%), and zinc (8%). The estimated value of U.S. industrial minerals production in 2017, including aggregates, was $48.9 billion, about 3% more than the revised value of 2016. The value of industrial minerals production in 2017 was dominated by crushed stone (31%), cement (20%), and construction sand and gravel (16%).

In 2017, U.S. production of 13 mineral commodities was valued at more than $1 billion each. These were, in decreasing order of value, crushed stone, gold, cement, copper, construction sand and gravel, industrial sand and gravel, iron ore, lime, zinc, phosphate rock, salt, soda ash, and clays (all types).

In 2017, 11 States each produced more than $2 billion worth of nonfuel mineral commodities. These States were, in descending order of production value, Nevada, Arizona, Texas, Alaska, California, Minnesota, Florida, Utah, Missouri, Michigan, and Wyoming (table 3).

The Defense Logistics Agency (DLA) Strategic Materials is responsible for providing safe, secure, and environmentally sound stewardship for strategic and critical materials in the U.S. National Defense Stockpile (NDS). DLA Strategic Materials stores 42 commodities at 8 locations in the United States. In fiscal year 2017, DLA Strategic Materials acquired $5.76 million of new materials and sold $63.24 million of excess materials from the NDS. At the end of fiscal year 2017, materials valued at $1.1 billion remained in the NDS. Of the remaining material, some was being held in reserve, some was offered for sale, and sales of some of the materials were suspended. Additional detailed information 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, the U.S. Geological Survey advises the DLA on acquisition and disposals of NDS mineral materials.

MAJOR IMPORT SOURCES OF NONFUEL MINERAL COMMODITIES FOR WHICH THE UNITED STATES WAS GREATER THAN 50% NET IMPORT RELIANT IN 2017



[1]In 2017, no countries qualified for the "13 to 18 commodities" category.

Source: U.S. Geological Survey

TABLE 1.—U.S. MINERAL INDUSTRY TRENDS

	2013	2014	2015	2016	2017[e]
Total mine production (million dollars):					
Metals	29,900	28,900	24,400	23,500	26,300
Industrial minerals	43,100	49,600	48,200	47,300	48,900
Coal	36,700	34,800	28,500	22,300	24,500
Employment (thousands of production workers):					
Coal mining	67	62	54	42	42
Nonfuel mineral mining	100	100	99	95	97
Chemicals and allied products	491	497	507	516	523
Stone, clay, and glass products	275	280	296	307	310
Primary metal industries	306	310	307	296	301
Average weekly earnings of production workers (dollars):					
Coal mining	1,362	1,435	1,387	1,336	1,430
Chemicals and allied products	918	917	928	951	1,010
Stone, clay, and glass products	782	828	842	850	870
Primary metal industries	959	991	987	1,003	997

[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

	2013	2014	2015	2016	2017[e]
Gross domestic product (billion dollars)	16,692	17,428	18,121	18,625	19,387
Industrial production (2012=100):					
Total index:	102	105	104	103	105
Manufacturing:	101	102	103	103	104
Nonmetallic mineral products	105	109	110	112	116
Primary metals:	103	104	97	94	96
Iron and steel	102	101	92	90	95
Aluminum	107	106	107	97	99
Nonferrous metals (except aluminum)	107	108	98	101	101
Chemicals	97	96	97	98	99
Mining:	106	117	112	102	109
Coal	97	98	87	70	75
Oil and gas extraction	111	126	134	129	134
Metals	102	105	100	101	102
Nonmetallic minerals	103	113	113	117	117
Capacity utilization (percent):					
Total industry:	77	79	77	76	77
Mining:	87	90	83	78	83
Metals	73	77	74	76	76
Nonmetallic minerals	82	89	87	87	86
Housing starts (thousands)	928	1,001	1,107	1,177	1,207
Light vehicle sales (thousands)[1]	15,880	16,860	17,850	17,870	17,550
Highway construction, value, put in place (billion dollars)	81	84	90	92	89

[e]Estimated.

[1]Excludes imports.

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

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2017[e, 1]

State	Value (millions)	Rank[2]	Percent of U.S. total	Principal minerals, in order of value
Alabama	$1,310	17	1.74	Stone (crushed), cement (portland), lime, sand and gravel (construction), cement (masonry).
Alaska	3,530	4	4.69	Zinc, gold, lead, silver, sand and gravel (construction).
Arizona	6,610	2	8.80	Copper, sand and gravel (construction), molybdenum concentrates, cement (portland), stone (crushed).
Arkansas	771	28	1.03	Stone (crushed) bromine, cement (portland), sand and gravel (construction), sand and gravel (industrial).
California	3,520	5	4.69	Sand and gravel (construction), cement (portland), boron minerals, stone (crushed), gold.
Colorado	1,680	14	2.23	Gold, cement (portland), sand and gravel (construction), molybdenum concentrates, stone (crushed).
Connecticut[3]	183	43	0.24	Stone (crushed), sand and gravel (construction), stone (dimension), clays (common), gemstones (natural).
Delaware[3]	25	50	0.03	Sand and gravel (construction), magnesium compounds, stone (crushed), gemstones (natural).
Florida	3,150	7	4.19	Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction), cement (masonry).
Georgia	1,840	13	2.44	Clays (kaolin), stone (crushed), sand and gravel (construction), cement (portland), clays (montmorillonite).
Hawaii	105	45	0.14	Stone (crushed), sand and gravel (construction), gemstones (natural).
Idaho[3]	191	42	0.25	Phosphate rock, sand and gravel (construction), stone (crushed), lead, silver.
Illinois[3]	1,380	16	1.84	Sand and gravel (industrial), stone (crushed), cement (portland), sand and gravel (construction), tripoli.
Indiana	1,020	25	1.35	Stone (crushed), cement (portland), sand and gravel (construction), lime, stone (dimension).
Iowa[3]	583	32	0.78	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), lime.
Kansas[3]	598	30	0.80	Helium (Grade-A), cement (portland), salt, stone (crushed), helium (crude).
Kentucky[3]	592	31	0.79	Stone (crushed), lime, cement (portland), sand and gravel (construction), sand and gravel (industrial).
Louisiana[3]	477	33	0.64	Salt, sand and gravel (construction), stone (crushed), sand and gravel (industrial), clays (common).
Maine[3]	104	46	0.14	Sand and gravel (construction), cement (portland), stone (crushed), stone (dimension), peat.
Maryland[3]	379	35	0.50	Cement (portland), stone (crushed), sand and gravel (construction), cement (masonry), stone (dimension).
Massachusetts[3]	296	37	0.39	Stone (crushed), sand and gravel (construction), stone (dimension), lime, clays (common).
Michigan	2,450	10	3.26	Iron ore, cement (portland), sand and gravel (construction), nickel concentrates, stone (crushed).
Minnesota[3]	3,180	6	4.23	Iron ore, sand and gravel (construction), sand and gravel (industrial), stone (crushed), stone (dimension).
Mississippi	216	40	0.29	Sand and gravel (construction), stone (crushed), clays (montmorillonite), sand and gravel (industrial), clays (ball).
Missouri	2,540	9	3.38	Cement (portland), stone (crushed), lime, lead, sand and gravel (industrial).
Montana	1,050	24	1.40	Palladium metal, copper, platinum metal, sand and gravel (construction), molybdenum concentrates.

See footnotes at end of table.

TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2017[e, 1]—Continued

State	Value (millions)	Rank[2]	Percent of U.S. total	Principal minerals, in order of value
Nebraska[3]	$192	41	0.26	Cement (portland), stone (crushed), sand and gravel (construction), sand and gravel (industrial), lime.
Nevada	8,680	1	11.55	Gold, copper, stone (crushed), sand and gravel (construction), silver.
New Hampshire	78	47	0.10	Stone (crushed), sand and gravel (construction), stone (dimension), gemstones (natural).
New Jersey	265	38	0.35	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), peat, gemstones.
New Mexico	1,310	18	1.74	Copper, potash, sand and gravel (construction), stone (crushed), cement (portland).
New York[3]	1,280	19	1.70	Salt, stone (crushed), sand and gravel (construction), cement (portland), clays (common).
North Carolina[3]	1,110	22	1.48	Stone (crushed) phosphate rock, sand and gravel (construction), sand and gravel (industrial), clays (common).
North Dakota[3]	72	48	0.10	Sand and gravel (construction), lime, stone (crushed), clays (common), sand and gravel (industrial).
Ohio[3]	1,080	23	1.43	Stone (crushed), salt, sand and gravel (construction), lime, cement (portland).
Oklahoma	700	29	0.93	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), gypsum (crude).
Oregon	474	34	0.63	Stone (crushed), sand and gravel (construction), cement (portland), diatomite, perlite (crude).
Pennsylvania[3]	1,850	12	2.47	Stone (crushed), cement (portland), lime, sand and gravel (construction), sand and gravel (industrial).
Rhode Island[3]	63	49	0.08	Stone (crushed), sand and gravel (construction), sand and gravel (industrial), gemstones (natural).
South Carolina[3]	784	27	1.04	Stone (crushed), cement (portland), gold, sand and gravel (construction), clays (kaolin).
South Dakota	372	36	0.49	Gold, cement (portland), sand and gravel (construction), stone (crushed), lime.
Tennessee	1,140	21	1.52	Stone (crushed), zinc, cement (portland), sand and gravel (construction), sand and gravel (industrial).
Texas	5,220	3	6.94	Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), lime.
Utah	2,610	8	3.48	Copper, magnesium metal, gold, potash, sand and gravel (construction).
Vermont[3]	149	44	0.20	Stone (crushed), sand and gravel (construction), stone (dimension), talc (crude), gemstones (natural).
Virginia	1,250	20	1.66	Stone (crushed), cement (portland), sand and gravel (construction), lime, kyanite.
Washington	901	26	1.20	Sand and gravel (construction), stone (crushed), gold, zinc, cement (portland).
West Virginia[3]	245	39	0.33	Stone (crushed), cement (portland), sand and gravel (industrial), lime, sand and gravel (construction).
Wisconsin[3]	1,490	15	1.98	Sand and gravel (industrial), stone (crushed), sand and gravel (construction), lime, stone (dimension).
Wyoming	2,410	11	3.21	Soda ash, helium (Grade-A), clays (bentonite), sand and gravel (construction), cement (portland).
Undistributed	3,680	XX	4.89	
Total	75,200	XX	100.00	

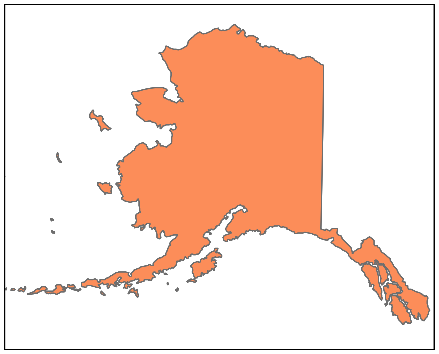
[e]Estimated. XX Not applicable.

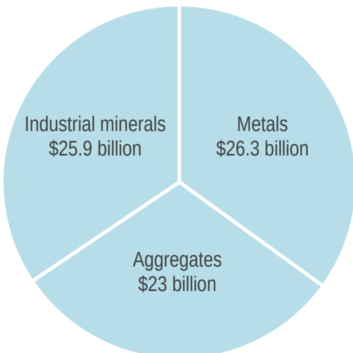
[1]Data are rounded to no more than three significant digits; may not add to totals shown.

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

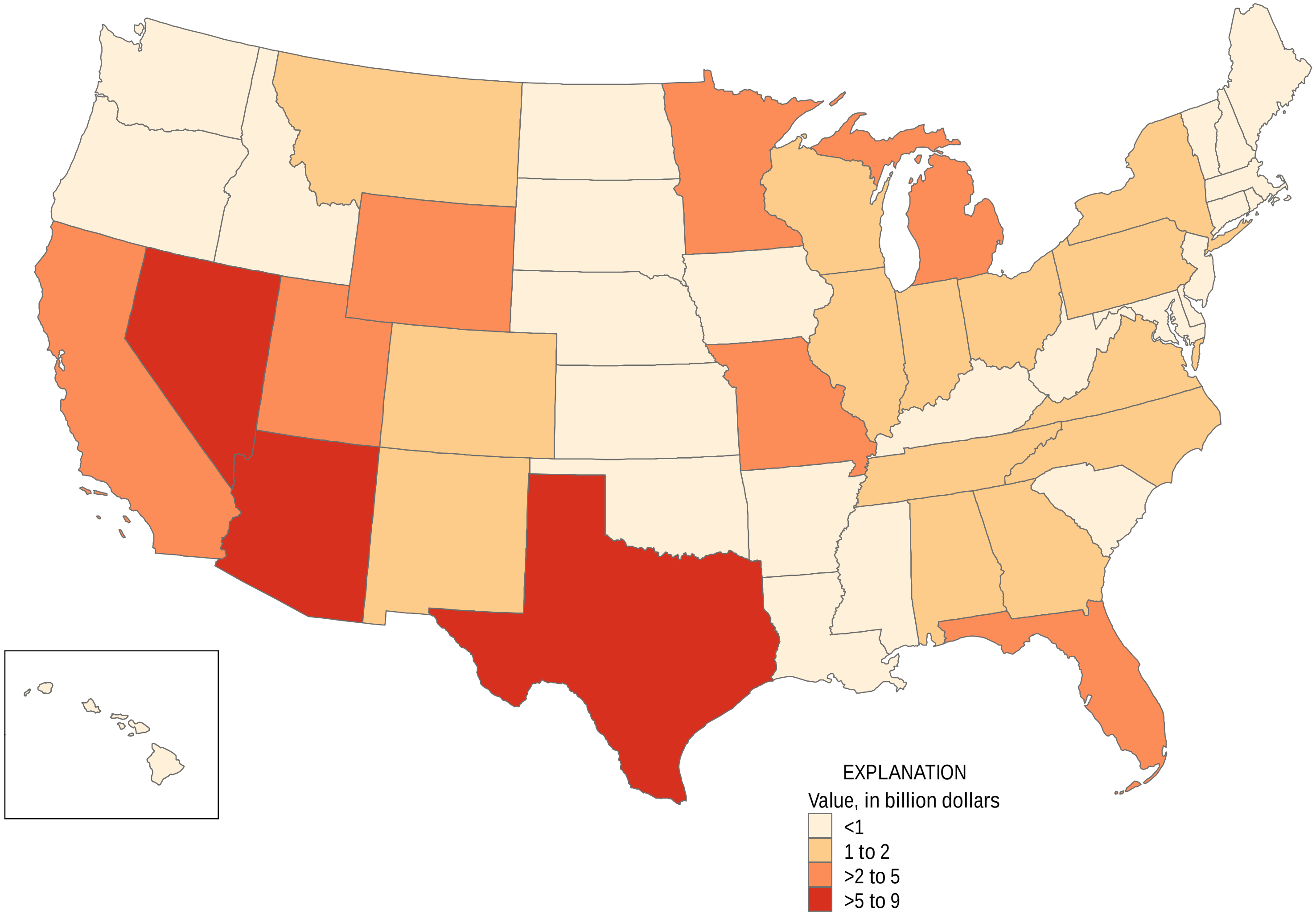
[3]Partial total; excludes values that must be withheld to avoid disclosing company proprietary data, which are included in "Undistributed."

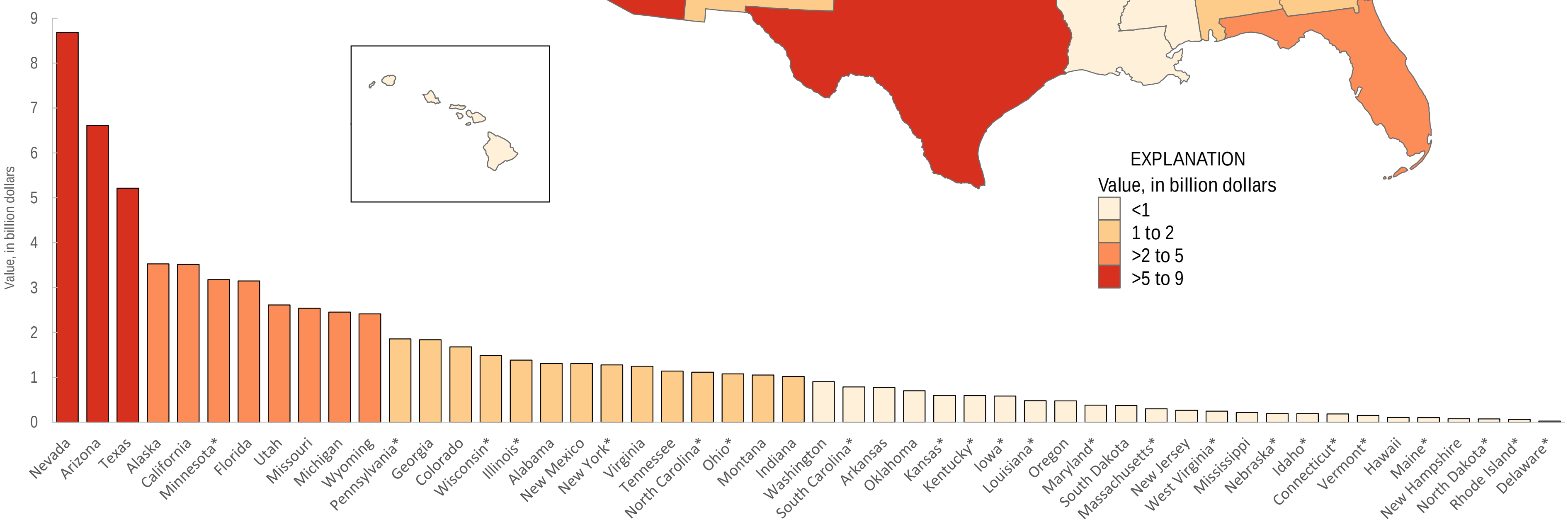
VALUE OF NONFUEL MINERALS PRODUCED IN 2017, BY STATE





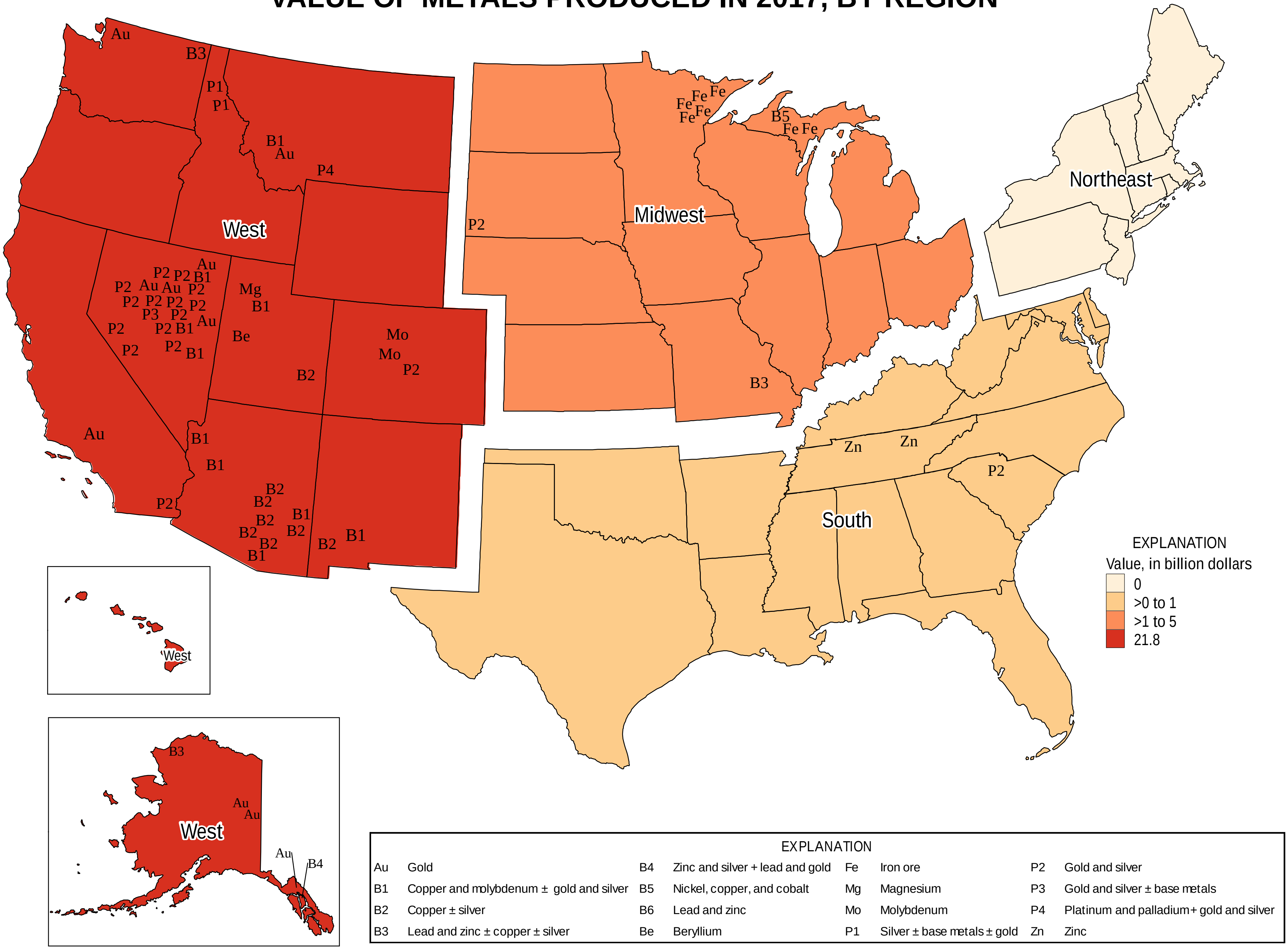
U.S. total: $75.2 billion



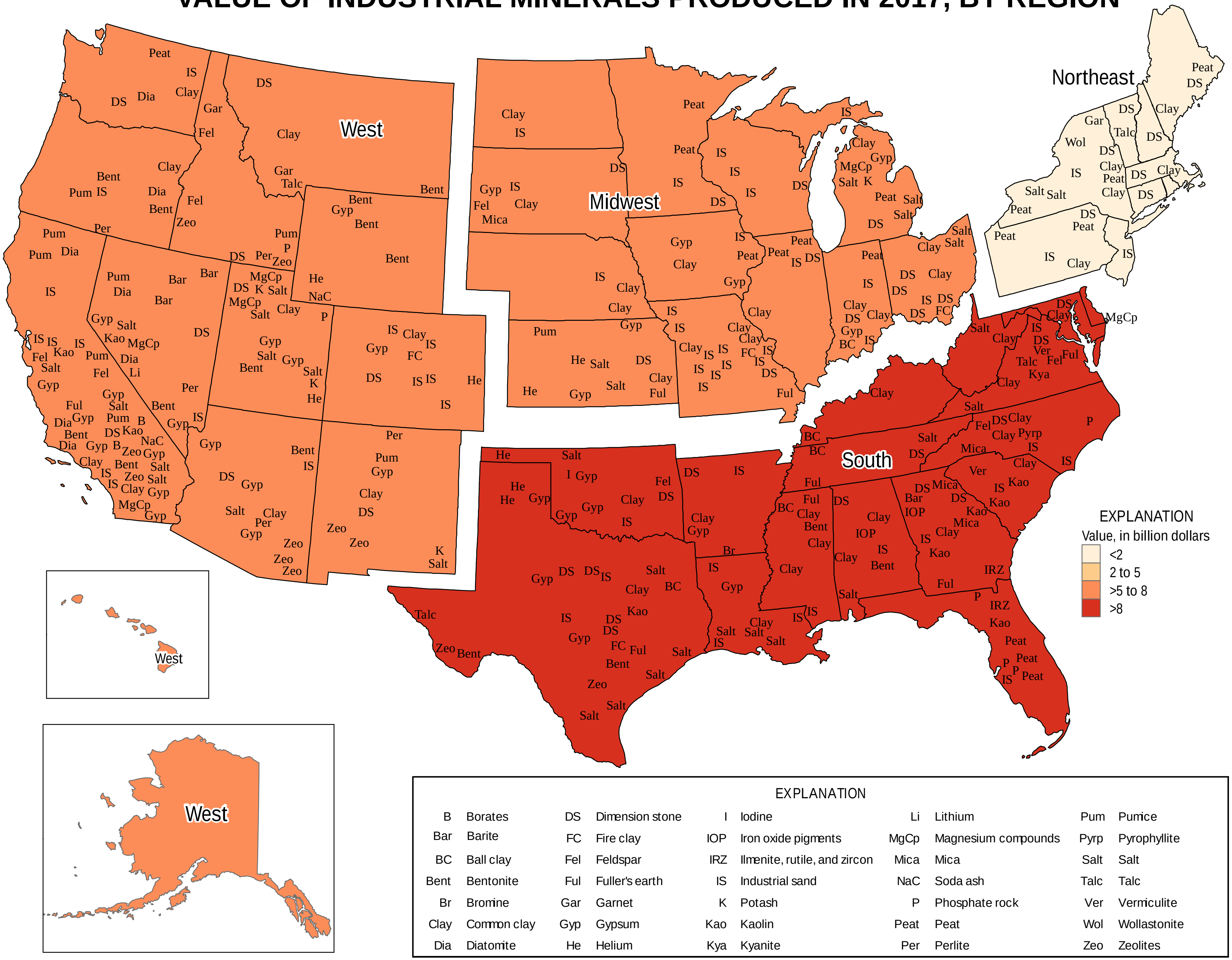


*Partial total; excludes values that must be withheld to avoid disclosing company proprietary data, which are included with "Undistributed" in table 3.

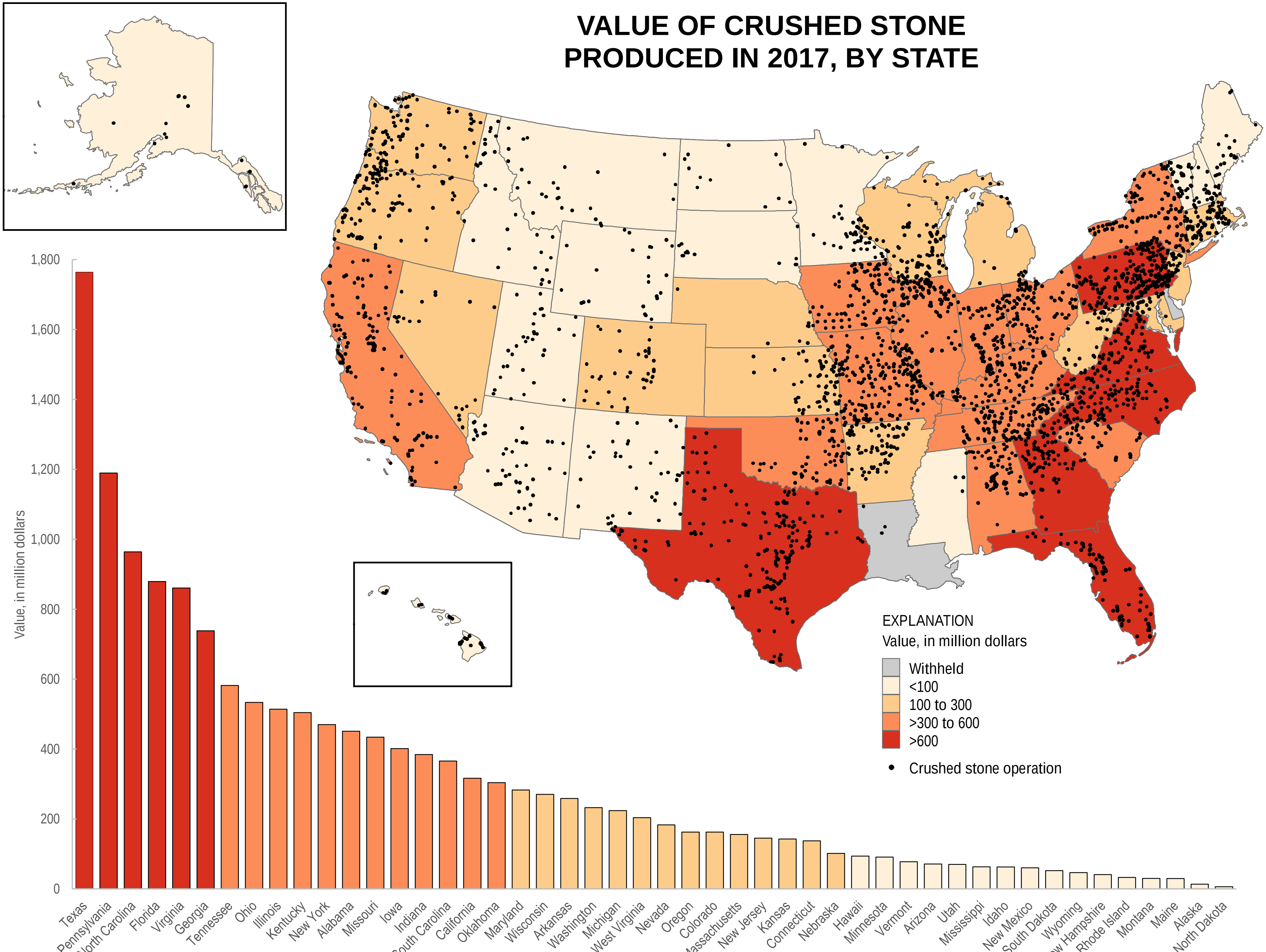
VALUE OF METALS PRODUCED IN 2017, BY REGION



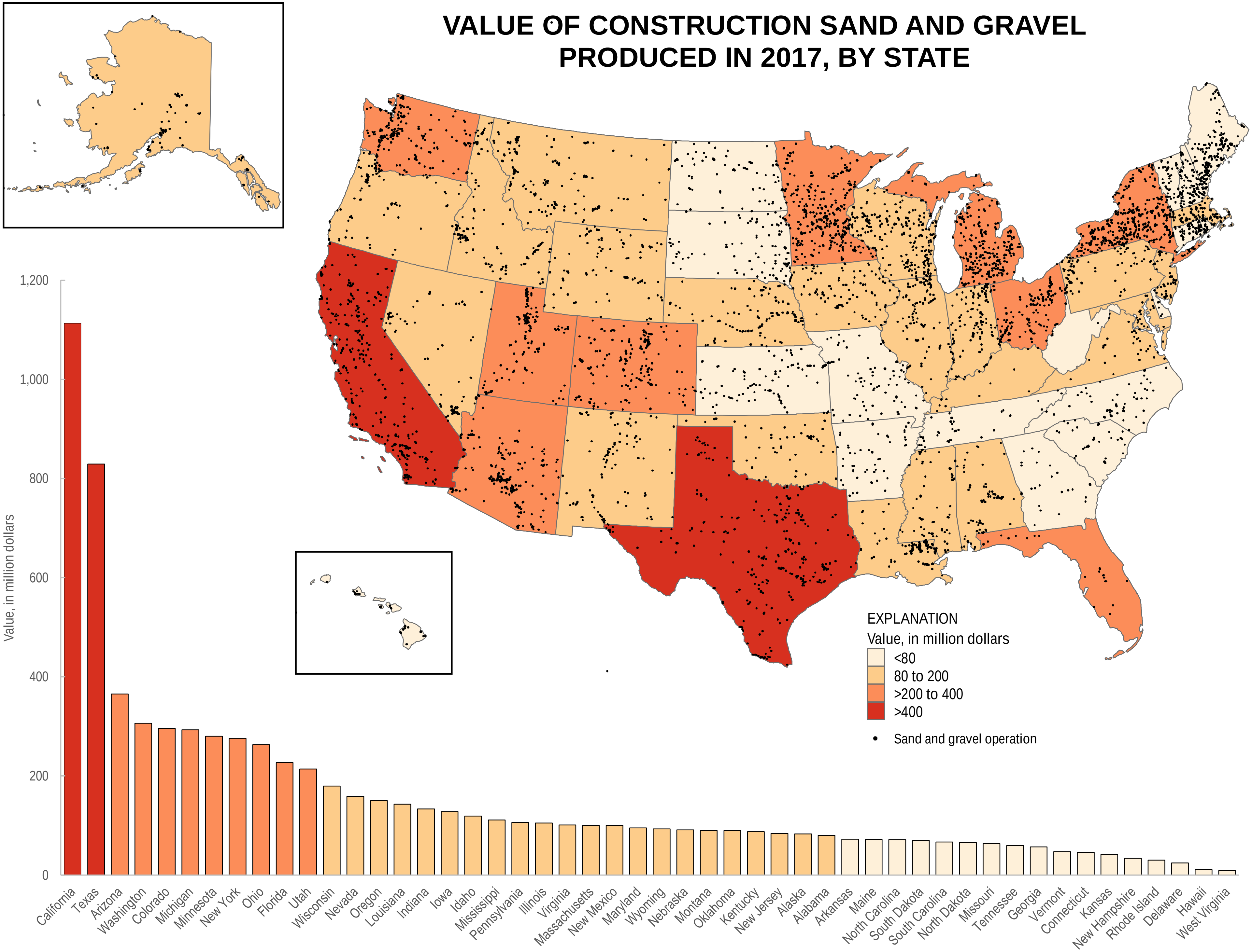
VALUE OF INDUSTRIAL MINERALS PRODUCED IN 2017, BY REGION



VALUE OF CRUSHED STONE PRODUCED IN 2017, BY STATE



VALUE OF CONSTRUCTION SAND AND GRAVEL PRODUCED IN 2017, BY STATE



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ABRASIVES (MANUFACTURED)

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

Domestic Production and Use: 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 $1.9 million. Silicon carbide was produced by two companies at two plants in the United States. Domestic production of crude silicon carbide had an estimated value of about $26.4 million. Domestic production of metallic abrasives had an estimated value of about $126 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 sand-blasting, surface-peening and stone-cutting applications.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production:					
Fused aluminum oxide, crude[1, 2]	10,000	10,000	10,000	10,000	10,000
Silicon carbide[2]	35,000	35,000	35,000	35,000	35,000
Metallic abrasives	191,000	194,000	206,000	188,000	180,000
Shipments, metallic abrasives	177,000	211,000	224,000	204,000	200,000
Imports for consumption:					
Fused aluminum oxide	209,000	198,000	164,000	155,000	210,000
Silicon carbide	119,000	130,000	139,000	116,000	140,000
Metallic abrasives	23,900	23,500	52,800	54,100	31,000
Exports:					
Fused aluminum oxide	24,500	19,500	15,000	14,200	16,000
Silicon carbide	18,400	22,300	19,700	6,810	5,900
Metallic abrasives	35,900	41,000	35,900	28,600	31,000
Consumption, apparent:					
Fused aluminum oxide[3]	185,000	179,000	149,000	141,000	190,000
Silicon carbide[4]	136,000	143,000	154,000	144,000	170,000
Metallic abrasives[5]	165,000	194,000	241,000	230,000	200,000
Price, average unit value of imports, dollars per ton:					
Fused aluminum oxide, regular	663	659	579	418	460
Fused aluminum oxide, high-purity	971	1,420	1,290	1,370	1,200
Silicon carbide, crude	638	660	552	452	480
Metallic abrasives	1,030	1,020	584	543	1,000
Net import reliance[6] as a percentage of apparent consumption:					
Fused aluminum oxide	>75	>75	>75	>75	>75
Silicon carbide	>50	>50	>75	>50	>75
Metallic abrasives	E	E	8	12	E

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

Import Sources (2013–16): Fused aluminum oxide, crude: China, 81%; Canada, 7%; France, 5%; and other, 7%. Fused aluminum oxide, grain: Austria, 18%; Jamaica, 17%; Brazil, 16%; Germany, 14%; and other, 35%. Silicon carbide, crude: China, 72%; Netherlands, 11%; South Africa, 11%; Romania, 4%; and other, 2%. Silicon carbide, grain: China, 49%; Brazil, 20%; Russia, 14%; Norway, 4%; and other, 13%. Metallic abrasives: Sweden, 35%; Canada, 28%; China, 10%; Germany, 8%; and other, 19%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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 val.
Artificial corundum, not elsewhere specified or included, fused aluminum oxide, grain	2818.10.2090	1.3% ad val.
Silicon carbide, crude	2849.20.1000	Free.
Silicon carbide, grain	2849.20.2000	0.5% ad val.
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 2017, China was the world's leading producer of abrasive fused aluminum oxide and abrasive silicon carbide, with producers operating nearly at capacity. Imports, especially from China where operating costs were lower, continued to challenge abrasives producers in the United States and Canada. Foreign competition, particularly from China, is expected to persist and continue to limit production in North America. Abrasives consumption in the United States is greatly influenced by activity in the manufacturing sectors, in particular 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]	
	2016	2017	2016	2017
United States	60,000	60,000	43,000	43,000
Argentina	—	—	5,000	5,000
Australia	50,000	50,000	—	—
Austria	60,000	60,000	—	—
Brazil	50,000	50,000	43,000	43,000
China	800,000	800,000	455,000	455,000
France	40,000	40,000	16,000	16,000
Germany	80,000	80,000	36,000	36,000
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	190,000	190,000
World total (rounded)	1,300,000	1,300,000	1,000,000	1,000,000

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

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

[e]Estimated. E Net exporter. — Zero.

[1]Production data for aluminum oxide are combined production data from Canada and the United States 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.

ALUMINUM[1]

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2017, two companies operated five primary aluminum smelters in four States. Three smelters operated at reduced capacity throughout the year. The status of a shutdown of one smelter that was announced as permanent in 2016 was changed to temporary in 2017, and the owner planned to restart production in early 2018. Three other smelters remained on standby throughout the year. Based on published market prices, the value of primary aluminum production was $1.61 billion, 8% more than the value in 2016. Aluminum consumption was centered in the Midwest United States. Transportation applications accounted for an estimated 41% of domestic consumption; in descending order of consumption, the remainder was used in packaging, 20%; building, 14%; electrical, 8%; machinery, 7%; consumer durables, 7%; and other, 3%.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production:					
Primary	1,946	1,710	1,587	841	740
Secondary (from old scrap)	1,630	1,690	1,560	1,580	1,600
Secondary (from new scrap)	1,790	1,870	2,000	2,010	2,100
Imports for consumption:					
Crude and semimanufactures	4,160	4,290	4,560	5,410	6,300
Scrap	565	559	521	609	730
Exports:					
Crude and semimanufactures	1,520	1,520	1,460	1,460	1,300
Scrap	1,870	1,720	1,550	1,350	1,500
Consumption, apparent[2]	4,520	5,070	5,300	5,120	5,980
Supply, apparent[3]	6,310	6,940	7,310	7,130	8,080
Price, ingot, average U.S. market (spot), cents per pound	94.2	104.5	88.2	80.4	98.5
Stocks:					
Aluminum industry, yearend	1,130	1,280	1,350	1,400	1,360
London Metal Exchange (LME), U.S. warehouses, yearend[4]	1,950	1,190	507	362	260
Employment, number[5]	30,100	30,900	31,000	31,900	28,000
Net import reliance[6] as a percentage of apparent consumption	21	33	41	53	61

Recycling: In 2017, aluminum recovered from purchased scrap in the United States was about 3.70 million tons, of which about 57% came from new (manufacturing) scrap and 43% from old scrap (discarded aluminum products). Aluminum recovered from old scrap was equivalent to about 27% of apparent consumption.

Import Sources (2013–16): Canada, 56%; Russia 8%; United Arab Emirates, 7%; China, 6%; and other, 23%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Aluminum, not alloyed:		
Unwrought (in coils)	7601.10.3000	2.6% ad val.
Unwrought (other than aluminum alloys)	7601.10.6000	Free.
Aluminum alloys:		
Unwrought (billet)	7601.20.9045	Free.
Aluminum waste and scrap:		
Used beverage container scrap	7602.00.0030	Free.
Other	7602.00.0090	Free.

Depletion Allowance: Not applicable.[1]

Government Stockpile: None.

Events, Trends, and Issues: U.S. production of primary aluminum decreased for the fifth consecutive year, declining by about 12% from that in 2016 and 64% from that in 2012. This was the lowest level since 1951 when production was 759,000 tons. In June, the owner of a 269,000-ton-per-year smelter in Evansville, IN, which was permanently shut down in 2016, announced that the shutdown would be revised to temporary and that about 160,000 tons per year of capacity would be restarted in 2018. In October, domestic smelters were operating at about 37% of capacity of 2 million tons per year.

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ALUMINUM

On July 7, the U.S. International Trade Commission reported the findings of its investigation of the aluminum industry that was requested by the U.S. House of Representatives Committee on Ways and Means in April 2016. The investigation examined the factors affecting competition in major unwrought and wrought aluminum-producing and aluminum-exporting countries, including the United States, as well as industry characteristics, recent trade trends, competitive strengths and weaknesses, factors related to increased capacity, and the effect of Government policies on production and trade of aluminum.[7]

On April 27, the President signed a memorandum instructing the Secretary of Commerce to conduct an investigation on the impact of aluminum imports on U.S. national security under the authority of Section 232 of the Trade Expansion Act of 1962. The Department of Commerce held a public hearing on June 22 as part of the investigation. If the investigation finds that aluminum is being imported in quantities or under circumstances which threaten to impair the national security, the Secretary of Commerce shall recommend actions and steps in his report to the President that need to be taken to adjust aluminum imports so that they will not threaten to impair the national security.

As prices generally increased throughout the year, world primary aluminum production increased slightly in 2017 compared with production in 2016. The U.S. market price for primary ingot quoted by Platts Metals Week averaged $0.90 per pound in January and gradually increased through May when it averaged $0.96 per pound. In June and July, the average price decreased to $0.94 per pound before resuming the upward trend in August and reached a monthly average of $1.06 per pound in October. Global LME warehouse inventories of primary aluminum metal decreased to 1.24 million tons in mid-October 2017 from 2.2 million tons at yearend 2016. Inventories, including primary aluminum and aluminum alloys, at LME-bonded warehouses in the United States decreased to about 260,000 tons in mid-October 2017 from 362,000 tons at yearend 2016.

World Smelter Production and Capacity:

	Production		Yearend capacity	
	2016	2017[e]	2016	2017[e]
United States	841	740	2,000	2,000
Australia	1,630	1,490	1,720	1,720
Bahrain	971	960	970	1,050
Brazil	793	800	1,400	1,400
Canada	3,210	3,210	3,270	3,270
China	31,900	32,600	43,200	44,500
Iceland	855	870	870	870
India	2,720	3,200	3,600	3,600
Malaysia	620	760	760	760
Norway	1,220	1,220	1,550	1,550
Russia	3,560	3,600	3,900	3,900
United Arab Emirates	2,500	2,600	2,500	2,600
Other countries	8,100	7,900	9,780	9,700
World total (rounded)	58,900	60,000	75,500	76,900

World Resources: Global resources of bauxite are estimated to be between 55 to 75 billion tons and are sufficient to meet world demand for metal well into the future.[1]

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.
[1]See also Bauxite and Alumina.
[2]Defined as domestic primary metal production + recovery from old aluminum scrap + net import reliance; excludes imported scrap.
[3]Defined as domestic primary metal production + recovery from all aluminum scrap + net import reliance; excludes imported scrap.
[4]Includes aluminum alloy.
[5]Alumina and aluminum production workers (North American Industry Classification System—3313). Source: U.S. Department of Labor, Bureau of Labor Statistics.
[6]Defined as imports – exports + adjustments for industry stock changes.
[7]U.S. International Trade Commission, 2017, Aluminum—Competitive conditions affecting the U.S. industry: U.S. International Trade Commission, publication 4703, July 7, 606 p. (Accessed July 10, 2017, at https://www.usitc.gov/publications/332/pub4703.pdf.)

ANTIMONY

(Data in metric tons of antimony content unless otherwise noted)

Domestic Production and Use: In 2017, no marketable antimony was mined in the United States. A mine in Nevada that had extracted about 800 tons of stibnite ore from 2013 through 2014 was placed on care-and-maintenance status in 2015 and had no reported production in 2017. Primary antimony metal and oxide were produced by one company in Montana using imported feedstock. Secondary antimony production was derived mostly from antimonial lead recovered from spent lead-acid batteries. The estimated value of secondary antimony produced in 2017, based on the average New York dealer price for antimony, was about $33 million. Recycling supplied about 15% of estimated domestic consumption, and the remainder came mostly from imports. The value of antimony consumption in 2017, based on the average New York dealer price, was about $228 million. The estimated distribution of domestic primary antimony consumption was as follows: nonmetal products, including ceramics and glass and rubber products, 31%; flame retardants, 31%; and metal products, including antimonial lead and ammunition, 38%.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production:					
Mine (recoverable antimony)	—	—	—	—	—
Smelter:					
Primary	W	W	W	W	W
Secondary	4,410	4,230	3,850	3,780	3,700
Imports for consumption:					
Ore and concentrates	342	378	308	119	100
Oxide, unwrought, powder, waste and scrap[1]	24,300	23,800	22,500	23,300	24,000
Exports:					
Ore and concentrates[1]	35	41	30	12	30
Oxide, unwrought, powder, waste and scrap[1]	3,970	3,240	3,200	1,950	2,200
Consumption, apparent[2]	24,700	24,900	23,200	25,300	25,000
Price, metal, average, cents per pound[3]	463	425	327	335	401
Stocks, yearend	1,470	1,400	1,290	1,090	1,100
Employment, plant, number (yearend)[e]	24	27	27	27	27
Net import reliance[4] as a percentage of apparent consumption	82	83	83	85	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 (2013–16): Metal: China, 62%; India, 13%; Mexico, 8%, Vietnam, 8%; and other, 9%. Ore and concentrate: Italy, 95%; Bosnia and Herzegovina, 3%; and Mexico, 2%. Oxide: China, 70%; Belgium, 11%; Bolivia, 6%; and other, 13%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Ore and concentrates	2617.10.0000	Free.
Antimony oxide	2825.80.0000	Free.
Antimony and articles thereof:		
Unwrought antimony; powder	8110.10.0000	Free.
Waste and scrap	8110.20.0000	Free.
Other	8110.90.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

Events, Trends, and Issues: One company operated a smelter in Montana that produced antimony metal and oxides from imported intermediate products (antimony oxides and sodium antimonate), primarily from Canada and Mexico, and a smelter in Mexico that processed concentrates from Australia and Mexico. The reported sales in the first 6 months of 2017 were 36% less than that sold in the same period of 2016.

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ANTIMONY

Starting in the fourth quarter of 2014 through the first quarter of 2016, the average quarterly antimony price decreased from $4.05 per pound to $2.60 per pound, its lowest level since 2009. Average quarterly prices then increased for the remainder of 2016 to $4.16 per pound in the fourth quarter of 2016. During 2017, the average quarterly antimony price was around $4.00 per pound.

China was the leading global antimony producer. In 2016, many large producers reduced production and many small producers closed in response to price declines and stricter environmental controls from Provincial and National governments. At the beginning of 2017, the Ministry of Commerce of China lifted the export quota for antimony, which was set at 54,400 tons in 2016, and introduced an export license system in its place. In the fall of 2017, as prices recovered, some private sector antimony producers began to reopen following antipollution checks.

World Mine Production and Reserves: Reserves estimates for Australia, China, and Turkey were revised based on Government sources.

	Mine production[e]		Reserves[5]
	2016	2017	
United States	—	—	[6]60,000
Australia	5,000	5,000	[7]140,000
Bolivia	2,670	2,600	310,000
Burma	3,000	2,000	NA
China	108,000	110,000	480,000
Guatemala	25	25	NA
Iran	200	200	NA
Kazakhstan	573	570	NA
Laos	242	240	NA
Mexico	196	200	18,000
Pakistan	114	100	NA
Russia (recoverable)	8,000	8,000	350,000
South Africa	1,200	1,200	27,000
Tajikistan	14,000	14,000	50,000
Turkey	4,000	3,500	100,000
Vietnam	643	600	NA
World total (rounded)	148,000	150,000	1,500,000

World Resources: U.S. resources of antimony are mainly in Alaska, Idaho, Montana, and Nevada. Principal identified world resources are in Australia, Bolivia, 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 + net import reliance.
[3]New York dealer price for 99.5% to 99.6% metal, c.i.f. U.S. ports.
[4]Defined as imports of antimony in oxide, unwrought, powder, waste and scrap – exports of antimony in oxide, unwrought, powder, waste and scrap + adjustments for industry stock changes.
[5]See Appendix C for resource and reserve definitions and information concerning data sources.
[6]Company-reported probable reserves for the Stibnite Gold Project in Idaho.
[7]For Australia, Joint Ore Reserves Committee-compliant reserves were about 65,000 tons.

ARSENIC

(Data in metric tons of arsenic content[1] unless otherwise noted)

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 trioxide was for the production of arsenic acid used in the formulation of chromated copper arsenide (CCA) preservatives for the pressure treating of lumber used primarily in nonresidential applications. Three companies produced CCA preservatives in the United States in 2017. Ammunition used by the U.S. military was hardened by the addition of less than 1% arsenic metal, and the grids in lead-acid storage batteries were strengthened by the addition of arsenic metal. Arsenic metal was also used as an antifriction additive for bearings, to harden lead shot, and in clip-on wheel weights. Arsenic compounds were used in herbicides and insecticides. High-purity arsenic (99.9999%) was used to produce gallium-arsenide (GaAs) semiconductors for solar cells, space research, and telecommunications. Arsenic also was used for germanium-arsenide-selenide specialty optical materials. Indium-gallium-arsenide (InGaAs) was used for short-wave infrared technology. The value of arsenic compounds and metal imported domestically in 2017 was estimated to be about $6.9 million.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Imports for consumption:					
Arsenic metal	514	688	514	793	1,000
Compounds	6,290	5,260	5,920	5,330	6,300
Exports, arsenic[2]	1,630	2,970	1,670	1,760	1,000
Estimated consumption[3]	6,810	5,940	6,430	6,120	7,300
Value, dollars per kilogram, average:					
Arsenic metal[4]	1.91	1.90	2.04	2.34	2.00
Trioxide (Morocco)[5]	0.60	0.66	0.64	0.68	0.70
Net import reliance[6] as a percentage of estimated consumption	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 (2013–16): Arsenic metal: China, 91%; Japan, 7%; and other, 2%. Arsenic trioxide: Morocco, 52%; China, 41%; Belgium, 6%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Arsenic	2804.80.0000	Free.
Arsenic acid	2811.19.1000	2.3% ad val.
Arsenic trioxide	2811.29.1000	Free.
Arsenic sulfide	2813.90.1000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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ARSENIC

Events, Trends, and Issues: China and Morocco continued to be the leading global producers of arsenic trioxide, accounting for 88% of estimated world production and supplying almost all of United States imports of arsenic trioxide in 2017. China was the leading world producer of arsenic metal and supplied about 90% of United States arsenic metal imports in 2017.

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 has been reported under this category reflects the gross weight of compounds, alloys, and residues containing arsenic. Therefore, the estimated consumption reported under salient U.S. statistics reflects only imports of arsenic products.

High-purity (99.9999%) arsenic metal was used to produce GaAs, indium-arsenide, and InGaAs semiconductors that were used in biomedical, communications, computer, electronics, and photovoltaic applications. The 2020 projected outlook for global GaAs device sales is estimated at $7.6 billion. See the Gallium chapter for additional details.

World Production and Reserves:

	Production[e, 7] (arsenic trioxide)		Reserves[8]
	2016	2017	
United States	—	—	
Belgium	1,000	1,000	World reserves data are unavailable, but reserves are thought to be more than 20 times annual world production.
Bolivia	40	40	
China	25,000	25,000	
Japan	45	45	
Morocco	7,600	7,600	
Namibia	1,900	1,900	
Russia	1,500	1,500	
World total (rounded)	37,000	37,000	

World Resources: 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 realgar and orpiment in China, Peru, and the Philippines; has been recovered from copper-gold ores in Chile; and was 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.

Substitutes: Substitutes for CCA in wood treatment include alkaline copper quaternary, ammoniacal copper quaternary, ammoniacal copper zinc arsenate, copper azole, and copper citrate. Treated wood substitutes include concrete, plastic composite material, plasticized wood scrap, or steel.

[e]Estimated. — Zero.
[1]Arsenic content of arsenic metal is 100%; arsenic content of arsenic compounds is calculated at 75.71%.
[2]Most of the materials reported to the U.S. Census Bureau as arsenic exports are thought to be arsenic-containing compounds or residues.
[3]Estimated to be the same as imports.
[4]Minimum 99% arsenic, free on board, United States warehouse. Source: Argus Media group-Argus Metals International.
[5]Calculated from U.S. Census Bureau import data.
[6]Defined as imports.
[7]Chile, Mexico, and Peru were believed to be significant producers of commercial-grade arsenic trioxide, but have reported no production in recent years.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.

ASBESTOS

(Data in metric tons unless otherwise noted)

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 markets associated with health and liability issues. The United States has since been wholly dependent on imports to meet manufacturing needs. In 2017, all of the asbestos minerals imported into and used within the United States consisted of chrysotile and were shipped from Brazil. Domestic consumption of asbestos minerals was estimated to be 300 tons, 57% less than 702 tons in 2016 and 22% less than 386 tons in 2015. Actual consumption of asbestos in 2016 may have been lower owing to stockpiling by companies, but information regarding industry stocks was unavailable. The chloralkali industry, which uses asbestos to manufacture semipermeable diaphragms that prevent chlorine generated at the anode of an electrolytic cell from reacting with sodium hydroxide generated at the cathode, accounted for nearly 100% of asbestos mineral consumption in 2017, based on bill of lading information obtained from a commercial trade database. In addition to asbestos minerals, an unknown quantity of asbestos was imported within manufactured products, including asbestos-containing brake linings, knitted fabric, rubber sheets for gasket manufacture, and potentially asbestos-cement pipe.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Imports for consumption[1]	772	406	386	702	300
Exports[2]	—	—	—	—	—
Consumption, estimated[3]	772	406	386	702	300
Price, average U.S. Customs value, dollars per ton	1,510	1,830	2,090	2,040	1,920
Net import reliance[4] as a percentage of estimated consumption	100	100	100	100	100

Recycling: None.

Import Sources (2013–16): Brazil, >99%; and Russia, <1%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
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 asbestos minerals in the United States has decreased during the past several decades, falling from a record high of 803,000 tons in 1973 to an estimated 300 tons in 2017. 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 accounted for nearly all domestic consumption of asbestos minerals in 2017, rising from an estimated 35% in 2010. However, the quantity of asbestos used by the chloralkali industry likely will continue to decline as companies make greater use of nonasbestos diaphragms and membrane cells.

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ASBESTOS

The Frank R. Lautenberg Chemical Safety for the 21st Century Act, which amended the Toxic Substances Control Act of 1976, was signed into law in 2016. The legislation granted the U.S. Environmental Protection Agency (EPA) greater authority to evaluate the hazards posed by new chemicals as well as those already in the marketplace. In 2017, the EPA released a report identifying the end uses, exposure pathways, and environmental and human health hazards that will be considered in the asbestos evaluation. If the agency ultimately determines that asbestos presents an unreasonable risk, it will be required to take mitigating actions.

Brazil accounted for roughly 10% of global asbestos production and consumption during 2017; in November, the Supreme Federal Court enacted a ban on the extraction, commercialization, and use of asbestos throughout the country. Pending further legal action, the only remaining commercial producers will be China, Kazakhstan, Russia, and potentially Zimbabwe, where two former asbestos mines will potentially reopen by yearend. The Government of Ukraine also banned the importation and use of asbestos and asbestos-containing products.

Based on revised production data, estimated worldwide consumption of asbestos minerals decreased from approximately 2 million tons in 2010 to nearly 1.4 million tons in 2016. Comprehensive data for 2017 were not yet available. Asbestos-cement products are expected to continue to be the leading global market for asbestos.

World Mine Production and Reserves: Production of asbestos in Brazil, China, and Russia in 2016 was revised downward based on new information from Government and industry sources. Reserves for Brazil, China, and Russia also were revised based on information from Government and industry sources.

	Mine production		Reserves[5]
	2016	2017[e]	
United States	—	—	Small
Brazil	[e]200,000	150,000	9,800,000
China	[e]200,000	200,000	96,000,000
Kazakhstan	193,000	210,000	Large
Russia	692,000	690,000	110,000,000
World total (rounded)	1,280,000	1,300,000	Large

World Resources: Reliable evaluations of global asbestos resources have not been published recently, and the available information is 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. Substitutes include 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. For the chloralkali industry, membrane cell technology is one alternative to asbestos diaphragms.

[e]Estimated. — Zero.

[1]Additional imports were reported by the U.S. Census Bureau for some years, but bill of lading information from a commercial trade database suggests that some of the shipments were misclassified.

[2]Exports of asbestos reported by the U.S. Census Bureau were 27 tons in 2013, 279 tons in 2014, 517 tons in 2015, 587 tons in 2016, and an estimated 120 tons in 2017. These shipments likely consisted of materials misclassified as asbestos, reexports, and (or) waste products because the United States no longer mines asbestos.

[3]Assumed to equal imports. A significant quantity of asbestos may have been added to company stockpiles in 2016, but information to make a reliable estimate was unavailable.

[4]Defined as imports – exports.

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

BARITE

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2017, domestic mine production decreased, but production data were withheld to avoid disclosing company proprietary data. An estimated 1.91 million tons of barite (from domestic production and imports) was sold by crushers and grinders operating in eight States. More than 90% of the barite sold in the United States was 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. 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, automobile paint primer for metal protection and gloss, use 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:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Sold or used, mine	826	663	439	240	W
Ground and crushed[1]	3,550	3,410	2,010	1,420	1,910
Imports for consumption[2]	2,250	2,700	1,660	1,290	2,220
Exports[3]	207	161	147	78	82
Consumption, apparent (crude and ground)[4]	2,870	3,210	1,960	1,450	W
Estimated price, ground, average value, dollars per ton, f.o.b. mill	181	191	194	187	170
Employment, mine and mill, number	624	614	458	300	340
Net import reliance[5] as a percentage of apparent consumption	71	79	78	83	>75

Recycling: None.

Import Sources (2013–16): China, 69%; India, 13%; Mexico, 9%; Morocco, 7%; and other, 2%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–17**
Ground barite	2511.10.1000	Free.
Crude barite	2511.10.5000	$1.25 per metric ton.
Oxide, hydroxide, and peroxide	2816.40.2000	2% ad val.
Other chlorides	2827.39.4500	4.2% ad val.
Other sulfates of barium	2833.27.0000	0.6% ad val.
Carbonate	2836.60.0000	2.3% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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BARITE

Events, Trends, and Issues: Sales from grinding plants in all States increased by an estimated 34% as compared with 2016. Sales in all regions, including Texas, Louisiana, and all other States, increased, but percentage increases differed significantly by region. Barite sales in Louisiana increased by 3%, sales in Texas increased by an estimated 96%, and sales in all other States increased by an estimated 18% compared with 2016. The pattern of recovery likely reflects the overall recovery in U.S. drilling activity, with most gains in drilling-rig count concentrated in the Permian Basin.

Domestic mine production continued to decrease. Only two mines and one temporary mining project were active throughout 2017. One mine that had been idled for approximately 3 years initiated closure activities, but intended to continue processing stockpiled ore. Recovery in drilling activity in the Central and Western United States was more muted, which likely prolonged the downturn in domestic mine production.

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 barite in 2010. This has likely stimulated exploration and expansion of global barite resources. Estimated reserves data are included only if developed since the adoption of the 4.1-specific gravity standard. Reserves data for China were revised based on Government information.

	Mine production		Reserves[6]
	2016	2017[e]	
United States	240	W	NA
China	2,800	3,100	37,000
India	1,050	1,100	32,000
Iran	480	500	24,000
Kazakhstan	482	500	85,000
Mexico	197	140	NA
Morocco	669	1,000	NA
Pakistan	107	140	14,000
Russia	434	430	12,000
Thailand	223	150	18,000
Turkey	170	200	35,000
Other countries	470	470	29,000
World total (rounded)	7,320	[7]7,700	290,000

World Resources: In the United States, identified resources of barite are estimated to be 150 million tons, and undiscovered resources contribute an additional 150 million tons. The world's barite resources in all categories are about 2 billion tons, but only about 740 million tons are identified resources. However, no known systematic assessment of either U.S. or global barite resources has been conducted since the 1980s.

Substitutes: In the drilling mud market, alternatives to barite include celestite, ilmenite, iron ore, and synthetic hematite that is manufactured in Germany. None of these substitutes, however, has had a major impact on the barite drilling mud industry.

[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]Imports calculated from Harmonized Tariff Schedule codes 2511.10.1000, 2511.10.5000, and 2833.27.0000.
[3]Exports calculated from Schedule B numbers 2511.10.1000, 2511.10.5000, and 2833.27.0000.
[4]Defined as sold or used by domestic mines + imports – exports.
[5]Defined as imports – exports.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]Excludes U.S. production.

BAUXITE AND ALUMINA[1]

(Data in thousand metric dry tons unless otherwise noted)

Domestic Production and Use: In 2017, the quantity of bauxite consumed, nearly all of which was imported, was estimated to be 4.2 million tons, 15% less than that in 2016, with an estimated value of about $130 million. More than 90% of the bauxite was refined by the Bayer process for alumina or aluminum hydroxide, and the remainder went to products such as abrasives, cement, chemicals, proppants, refractories, and as a slag adjuster in steel mills. Three domestic Bayer-process refineries had a combined alumina production capacity of 4 million tons per year. Two of the refineries produced an estimated 1.5 million tons in 2017; the other refinery has remained on care-and-maintenance status since 2016. About 60% 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:	2013	2014	2015	2016	2017[e]
Bauxite:					
Production, mine	W	W	W	W	W
Imports for consumption[2]	10,800	11,800	11,600	6,000	4,300
Exports[2]	21	15	21	40	40
Stocks, industry, yearend[2]	1,300	1,210	1,500	880	940
Consumption:					
Apparent[3]	W	W	W	W	W
Reported	10,200	9,840	9,660	4,940	4,200
Price, average value, U.S. imports (f.a.s.), dollars per ton	27	27	28	28	30
Net import reliance[4] as a percentage of apparent consumption	>75	>75	>75	>75	>75
Alumina:					
Production, refinery[5]	4,320	4,460	4,550	2,360	1,500
Imports for consumption[5]	2,050	1,630	1,570	1,140	1,300
Exports[5]	2,250	2,130	2,240	1,370	450
Stocks, industry, yearend[5]	280	276	274	245	200
Consumption, apparent[3]	4,210	3,970	3,880	2,170	2,400
Price, average value, U.S. imports (f.a.s.), dollars per ton	368	394	400	362	450
Net import reliance[4] as a percentage of apparent consumption	15	E	E	E	37

Recycling: None.

Import Sources (2013–16): Bauxite: Jamaica, 46%; Brazil, 30%; Guinea, 21%; Guyana, 2%; and other, 1%. Alumina[5]: Australia, 39%; Suriname, 24%; Brazil, 20%; Jamaica, 5%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Bauxite, calcined (refractory grade)	2606.00.0030	Free.
Bauxite, calcined (other)	2606.00.0060	Free.
Bauxite, crude dry (metallurgical grade)	2606.00.0090	Free.
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 2017, two domestic alumina refineries produced alumina from imported bauxite. A 500,000-ton-per-year alumina refinery in Burnside, LA, produced specialty-grade alumina. A 1.2-million-ton-per-year alumina refinery in Gramercy, LA, produced alumina principally for aluminum smelting. Facilities at the 200,000-ton-per-year Gramercy refinery were being upgraded to produce higher value-added specialty alumina in a project scheduled for completion in 2018.

The average price free alongside ship (f.a.s.) for U.S. imports for consumption of metallurgical-grade alumina during the first 8 months of 2017 was $456 per ton, 34% higher than that of the same period in 2016, and ranged between $395 per ton and $576 per ton. World alumina production through October 2017 increased by 13% compared with

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BAUXITE AND ALUMINA

that of the same period in 2016. For the first 9 months of 2017, the estimated average price (f.a.s.) for U.S. imports for consumption of crude-dry bauxite was $29 per ton, slightly higher than that of the same period in 2016. The owner of one of the alumina refineries in the United States also owned the mine which supplied imported bauxite. The other alumina refinery in the United States purchased bauxite from unrelated mines.

In June, the Government of Indonesia permitted exports of bauxite for the first time since January 2014 when exports were prohibited as part of a mining law. Export permits were issued for 5 years to companies that were constructing refineries in Indonesia. Two refineries have been completed in Indonesia since 2015 and another under construction was expected to be completed in 2019. The Government of Malaysia continued its ban on bauxite mining through at least yearend 2017 but did permit exports of stockpiled bauxite. The ban was imposed in January 2016 because of concerns about pollution from mines and uncovered stockpiles at ports. In June, an alumina refinery and an adjacent bauxite mine in Jamaica that had been shut down since 2009 were restarted by a new owner.

World Alumina Refinery and Bauxite Mine Production and Bauxite Reserves: Reserves data for Australia, China, Greece, India, Russia, and Vietnam were updated based on Government data and other sources.

	Alumina[5]		Bauxite		Reserves[6]
	2016	2017[e]	2016	2017[e]	
United States	2,360	1,500	W	W	20,000
Australia	20,900	20,600	82,000	83,000	[7]6,000,000
Brazil	10,900	11,000	34,400	36,000	2,600,000
Canada	1,570	1,570	—	—	—
China	60,900	72,300	65,000	68,000	1,000,000
Germany	1,900	1,900	—	—	—
Greece	821	820	1,800	1,800	250,000
Guinea	—	—	31,500	45,000	7,400,000
Guyana	—	—	1,700	1,500	850,000
India	6,030	6,170	23,900	27,000	830,000
Indonesia	600	1,500	1,400	3,600	1,000,000
Ireland	1,970	1,930	—	—	—
Jamaica	1,870	1,980	8,540	8,100	2,000,000
Kazakhstan	1,500	1,500	5,000	5,000	160,000
Malaysia	—	—	1,000	1,000	110,000
Russia	2,680	2,800	5,430	5,600	500,000
Saudi Arabia	1,430	1,450	3,840	3,900	210,000
Spain	1,580	1,570	—	—	—
Ukraine	1,510	1,660	—	—	—
Vietnam	600	600	1,200	2,000	3,700,000
Other countries	2,160	2,130	7,820	9,030	3,200,000
World total (rounded)	121,000	130,000	275,000	300,000	30,000,000

World Resources: Bauxite resources are estimated to be 55 billion to 75 billion tons, 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 bauxite-based abrasives but cost more.

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

[1]See also Aluminum. As a general rule, 4 tons of dried bauxite is required to produce 2 tons of alumina, which, in turn, produces 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 reserves were about 2.3 billion tons.

BERYLLIUM

(Data in metric tons of beryllium content unless otherwise noted)

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. Based on the estimated unit value for beryllium in imported beryllium-copper master alloy, beryllium apparent consumption of 200 tons was valued at about $125 million. Based on value-added sales revenues, approximately 21% of beryllium products were used in consumer electronics, 19% in industrial components, 14% in automotive electronics, 11% in defense applications, 9% in telecommunications infrastructure, 6% in energy applications, 2% in medical applications, and 18% in other applications. Beryllium alloy strip and bulk products, the most common forms of processed beryllium, were used in all application areas. The majority of unalloyed beryllium metal and beryllium composite products were used in defense and scientific applications.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, mine shipments	235	270	205	155	170
Imports for consumption[1]	57	68	66	68	49
Exports[2]	35	26	29	34	33
Government stockpile releases[3]	10	1	1	3	2
Consumption:					
Apparent[4]	262	318	233	182	200
Reported, ore	250	280	220	160	185
Unit value, annual average, beryllium-copper master alloy, dollars per kilogram contained beryllium[5]	460	470	490	510	630
Stocks, ore, consumer, yearend	20	15	25	35	25
Net import reliance[6] as a percentage of apparent consumption	10	15	12	15	14

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 are not available but may account for as much as 20% to 25% of total beryllium consumption. The leading U.S. beryllium producer established a comprehensive recycling program for all of its beryllium products, recovering approximately 40% of the beryllium content of the new and old beryllium alloy scrap. Beryllium manufactured from recycled sources requires only 20% of the energy as that of beryllium manufactured from primary sources.

Import Sources (2013–16):[1] Kazakhstan, 47%; Japan, 14%; Brazil, 8%; United Kingdom, 8%; and other, 23%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Beryllium ores and concentrates	2617.90.0030	Free.
Beryllium oxide and hydroxide	2825.90.1000	3.7% ad val.
Beryllium-copper master alloy	7405.00.6030	Free.
Beryllium-copper plates, sheets, and strip:		
Thickness of 5 millimeters (mm) or more	7409.90.1030	3.0% ad val.
Thickness of less than 5 mm:		
Width of 500 mm or more	7409.90.5030	1.7% ad val.
Width of less than 500 mm	7409.90.9030	3.0% ad val.
Beryllium:		
Unwrought, including powders	8112.12.0000	8.5% ad val.
Waste and scrap	8112.13.0000	Free.
Other	8112.19.0000	5.5% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

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BERYLLIUM

Government Stockpile: The Defense Logistics Agency Strategic Materials had a goal of retaining 47 tons of beryllium metal in the National Defense Stockpile.

Stockpile Status—9–30–17[7]

Material	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Beryl ore	1	—	—
Metal	67	2	2
Structured powder	7	—	—

Events, Trends, and Issues: Apparent consumption of beryllium-based products was estimated to have increased by about 10% in 2017 from that of 2016. During the first 6 months of 2017, 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 7% higher than those during the first 6 months of 2016. Sales of beryllium products to the consumer electronics, industrial components, and commercial aerospace markets increased owing to stronger demand, and sales of beryllium hydroxide increased owing to a new supply agreement with an existing customer. Sales of beryllium products to the defense industry decreased during the first quarter of 2017.

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[e]		Reserves[8]
	2016	2017	
United States	155	170	The United States has very little beryl that can be economically hand sorted from pegmatite deposits. The Spor Mountain area in Utah, an epithermal deposit, contains a large bertrandite resource, which is being mined. Proven bertrandite reserves in Utah total about 18,000 tons of contained beryllium. World beryllium reserves are not available.
Brazil	5	3	
China	50	50	
Madagascar	6	6	
Nigeria	6	NA	
Rwanda	1	NA	
World total (rounded)	220	230	

World Resources: 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 size, 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. — Zero. NA Not available.
[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 level from prior yearend inventory.
[4]Defined as production + net import reliance.
[5]Calculated from gross weight and customs value of imports; beryllium content estimated to be 4%.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]See Appendix B for definitions.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.

BISMUTH

(Data in metric tons gross weight unless otherwise noted)

Domestic Production and Use: The United States ceased production of primary refined bismuth in 1997 and is highly import dependent for its supply. Bismuth is contained in some lead ores mined domestically, but the last domestic primary lead smelter closed at yearend 2013, and all lead concentrates now are exported for smelting. In 2017, the estimated value of apparent consumption of bismuth was approximately $22 million.

About two-thirds of domestic bismuth consumption was for chemicals used in cosmetic, industrial, laboratory, and pharmaceutical applications. Bismuth use in pharmaceuticals included bismuth salicylate (the active ingredient in over-the-counter stomach remedies) and other compounds used to treat burns, intestinal disorders, and stomach ulcers. Bismuth also is used in the manufacture of ceramic glazes, crystalware, and pearlescent pigments. Bismuth has a wide variety of metallurgical applications, including use as a nontoxic replacement for lead in brass, free-machining steels, and solders, and as an additive to enhance metallurgical quality in the foundry industry. The Safe Drinking Water Act Amendment of 1996, which required that all new and repaired fixtures and pipes for potable water supply be lead free after August 1998, opened a wider market for bismuth as a metallurgical additive to lead-free pipe fittings, fixtures, and water meters. Bismuth is used as a triggering mechanism for fire sprinklers and in holding devices for grinding optical lenses, and bismuth-tellurium-oxide alloy film paste is used in the manufacture of semiconductor devices.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Refinery	—	—	—	—	—
Secondary (old scrap)[e]	80	80	80	80	80
Imports for consumption, metal, alloys, and scrap	1,710	2,270	1,950	2,190	2,400
Exports, metal, alloys, and scrap	857	567	519	421	400
Consumption:					
Reported	774	727	662	733	770
Apparent[1]	1,010	1,500	1,380	1,670	2,080
Price, average, domestic dealer, dollars per pound	8.71	11.14	6.43	4.53	4.8
Stocks, yearend, consumer	50	329	464	643	640
Net import reliance[2] as a percentage of apparent consumption	92	95	94	95	96

Recycling: Bismuth-containing new and old alloy scrap was recycled and thought to compose less than 5% of U.S. bismuth apparent consumption, or about 80 tons.

Import Sources (2013–16): China, 77%; Belgium, 12%; Peru, 3%; and other, 8%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Bismuth and articles thereof, including waste and scrap	8106.00.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

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BISMUTH

Events, Trends, and Issues: The U.S. domestic dealer price of bismuth, which had trended upward in 2014, started 2015 at $10.90 per pound, decreased steadily throughout the year, and ended the year with a December average of $4.56 per pound. The price then remained relatively stable throughout 2016 and 2017, ranging between $4.00 per pound and $5.17 per pound.

In China, new environmental regulations were reported to have reduced the number of operating bismuth producers, from between 70 and 80 in 2016 to between 40 and 50 in 2017. Small- and medium-sized producers were forced to shut down for upgrades to meet stricter regulations, reducing domestic output by at least 25%.

World Refinery Production and Reserves: Mine production and reserves data were reevaluated, and available information was inadequate to make reliable estimates.

	Refinery production		Reserves[3]
	2016	2017[e]	
United States	—	—	Quantitative estimates of reserves are not available.
Canada	[e]25	25	
China	[e]14,000	11,000	
Japan	428	430	
Kazakhstan	140	140	
Laos	2,000	2000	
Mexico	539	540	
Russia	4	4	
World total (rounded)	17,100	14,000	

World Resources: Bismuth, at an estimated 8 parts per billion by weight, ranks 69th in elemental abundance in the Earth's crust and is about twice as abundant as gold. World reserves of bismuth are usually estimated based on the bismuth content of lead resources because bismuth production is most often a byproduct of processing lead ores. In China and Vietnam, bismuth production is a byproduct or coproduct of tungsten and other metal ore processing. Bismuth minerals rarely occur in sufficient quantities to be mined as principal products; the Tasna Mine in Bolivia and a mine in China are the only mines where bismuth has been the primary product. The Tasna Mine in Bolivia has been inactive since 1996.

Substitutes: Bismuth compounds can be replaced in pharmaceutical applications by alumina, antibiotics, and magnesia. Titanium dioxide-coated mica flakes and fish-scale extracts are substitutes in pigment uses. Indium can replace bismuth in low-temperature solders. Resins can replace bismuth alloys for holding metal shapes during machining, and glycerine-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. — Zero.

[1]Defined as secondary 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.

BORON

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Two companies in southern California produced borates in 2017, and most of the boron products consumed in the United States were manufactured domestically. U.S. boron production and consumption data were withheld to avoid disclosing company proprietary data. The leading boron producer mined borate ores containing 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. Boron minerals and chemicals were principally consumed in the North Central and the Eastern United States. In 2017, the glass and ceramics industries remained the leading domestic users of boron products, accounting for an estimated 80% of total borates consumption. Boron also was used as a component in abrasives, cleaning products, insecticides, insulation, and in the production of semiconductors.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production	W	W	W	W	W
Imports for consumption:					
Refined borax	127	152	136	173	140
Boric acid	53	57	40	46	35
Colemanite (calcium borates)	38	45	35	35	39
Ulexite (sodium borates)	—	34	70	43	23
Exports:					
Boric acid	232	226	195	241	140
Refined borax	489	584	504	552	500
Consumption, apparent[1]	W	W	W	W	W
Price, average value of mineral imports					
Cost, insurance and freight, dollars per ton	433	372	400	550	500
Employment, number	1,180	1,180	1,180	1,180	1,180
Net import reliance[2] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2013–16): Borates: Turkey, 78%; Bolivia, 15%; Chile, 3%; Argentina, 1%; and other, 3%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Natural borates:		
Sodium (ulexite)	2528.00.0005	Free.
Calcium (colemanite)	2528.00.0010	Free.
Boric acids	2810.00.0000	1.5% ad val.
Borates:		
Refined borax:		
Anhydrous	2840.11.0000	0.3% ad val.
Non-anhydrous	2840.19.0000	0.1% ad val.

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

Government Stockpile: None.

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BORON

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 content (B_2O_3), varying by ore and compound and by the absence or presence of calcium and sodium. The four borate minerals—colemanite, kernite, tincal, and ulexite—make up 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.

Canada, China, India, Malaysia, and the Netherlands are the countries that imported the largest quantities of refined borates from the United States in 2017. Because China has low-grade boron reserves and demand for boron is anticipated to rise in that country, imports to China from Chile, Russia, Turkey, and the United States were expected to remain steady during the next several years. In Europe and developing countries, more stringent building standards with respect to heat conservation were being enacted. Consequently, increased consumption of borates for fiberglass insulation was expected. Continued investment in new borate refineries and technologies and the continued rise in demand were expected to fuel growth in world production during the next several years.

World Production and Reserves: Reserves for Turkey were updated based on Government information.

	Production—All forms		Reserves[3]
	2016	2017[e]	
United States	W	W	40,000
Argentina	450	450	NA
Bolivia	150	150	NA
Chile	518	520	35,000
China	160	160	32,000
Kazakhstan	500	500	NA
Peru	663	660	4,000
Russia	80	80	40,000
Turkey	7,300	7,300	950,000
World total (rounded)	[4]9,820	[4]9,800	1,100,000

World Resources: Deposits of borates are associated with volcanic activity and arid climates, with the largest economically viable deposits located in the Mojave Desert of the United States, the Alpide belt in southern Asia, 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. — Zero.

[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.

BROMINE

(Data in metric tons of bromine content unless otherwise noted)

Domestic Production and Use: Bromine was recovered from underground brines by two companies in Arkansas. Bromine often is the leading mineral commodity, 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, intermediates and industrial uses, drilling fluids, and water treatment, in descending order by quantity. Bromine compounds are also used in a variety of other applications, including the control of mercury emissions from coal-fired powerplants and in specialty rubbers, particularly for tire manufacturing.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production	W	W	W	W	W
Imports for consumption, elemental bromine and compounds[1]	36,300	57,600	58,000	58,400	55,000
Exports, elemental bromine and compounds[2]	18,200	20,600	25,000	25,200	31,400
Consumption, apparent[3]	W	W	W	W	W
Employment, number[e]	1,050	1,050	1,050	1,050	1,050
Net import reliance[4] as a percentage of apparent consumption	<50	<50	<50	<50	<50

Recycling: Some bromide solutions were recycled to obtain elemental bromine and to prevent the solutions from being disposed of as hazardous waste. Hydrogen bromide is emitted as a byproduct in many organic reactions. This byproduct waste can be recycled with virgin bromine brines and used as a source of bromine production. Almost 50% of production came from recycled or byproduct bromides at one U.S. producer. Bromine contained in plastics can be incinerated as solid organic waste, and the bromine can be recovered.

Import Sources (2013–16):[5] Israel, 84%; China, 7%; Jordan, 5%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Bromine	2801.30.2000	5.5% ad val.
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.
Ethylene dibromide	2903.31.0000	5.4% ad val.
Methyl bromide	2903.39.1520	Free.
Dibromoneopentyl glycol	2905.59.3000	Free.
Tetrabromobisphenol A	2908.19.2500	5.5% ad val.
Decabromodiphenyl and octabromodiphenyl oxide	2909.30.0700	5.5% ad val.

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

Government Stockpile: None.

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BROMINE

Events, Trends, and Issues: The United States maintained its position as one of the leading bromine producers in the world. China, Israel, and Jordan also are major producers of elemental bromine. In 2017, U.S. imports of bromine and bromine compounds decreased, and exports increased.

U.S. companies did not announce prices for bromine and bromine compounds in 2017. Trade publications, however, reported that U.S. bromine prices ranged from about $4,400 to $5,400 per metric ton during the year, essentially unchanged compared with 2016 prices. Global demand for brominated flame retardants continued to be strong in 2017. However, demand for clear brine fluids used in the oil-well- and gas-well-drilling industries remained weak in 2017 owing to low oil prices.

The use of bromine to mitigate mercury emissions continued to be an area of growth for the bromine industry owing to the finalized rules set by the U.S. Environmental Protection Agency's Mercury and Air Toxics Standards, which require coal- and oil-fired powerplants to limit their emissions of air pollutants such as mercury and arsenic. Bromine compounds bond with mercury in flue gases from coal-fired powerplants creating mercuric bromide, a substance that is more easily captured in flue-gas scrubbers than the mercuric chloride that is produced at many facilities.

World Production and Reserves: Production for China was revised based on Government reports.

	Production		Reserves[6]
	2016	2017[e]	
United States	W	W	11,000,000
Azerbaijan	—	—	300,000
China	57,600	60,000	NA
India	1,700	1,700	NA
Israel	162,000	162,000	NA
Japan	20,000	20,000	NA
Jordan	100,000	100,000	NA
Turkmenistan	500	500	700,000
Ukraine	3,500	3,500	NA
World total (rounded)	[7]345,000	[7]350,000	Large

World Resources: Bromine is found principally in seawater, evaporitic (salt) lakes, and underground brines associated with petroleum deposits. The Dead Sea, in the Middle East, is estimated to contain 1 billion tons of bromine. Seawater contains about 65 parts per million of bromine, or an estimated 100 trillion tons. Bromine is also 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-well 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. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Imports calculated from items shown in Tariff section.
[2]Exports calculated from Schedule B numbers 2801.30.2000, 2827.51.0000, 2827.59.0000, 2903.31.0000, and 2903.39.1520.
[3]Defined as production (sold or used) + imports – exports.
[4]Defined as imports – exports.
[5]Calculated using the gross weight of imports.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]Excludes U.S. production.

CADMIUM

(Data in metric tons of cadmium content unless otherwise noted)

Domestic Production and Use: Two companies in the United States produced refined cadmium in 2017. One company, operating in Tennessee, recovered primary refined cadmium as a byproduct of zinc leaching from roasted sulfide concentrates. The other company, operating in Ohio, recovered secondary cadmium metal from spent nickel-cadmium (NiCd) batteries. Domestic production and consumption of cadmium were withheld to avoid disclosing company proprietary data. Cadmium metal and compounds are mainly consumed for alloys, coatings, NiCd batteries, pigments, and plastic stabilizers.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, refined[1]	W	W	W	W	W
Imports for consumption:					
Unwrought cadmium and powders	284	133	237	240	290
Wrought cadmium and other articles (gross weight)	104	6	18	([2])	2
Cadmium waste and scrap (gross weight)	([2])	—	71	52	50
Exports:					
Unwrought cadmium and powders	131	198	350	157	140
Wrought cadmium and other articles (gross weight)	266	72	246	371	190
Cadmium waste and scrap (gross weight)	20	—	([2])	12	([2])
Consumption, reported, refined	W	W	W	W	W
Price, metal, annual average, dollars per kilogram[3]	1.92	1.94	1.47	1.34	1.70
Stocks, yearend, producer and distributor	W	W	W	W	W
Net import reliance[4] as a percentage of apparent consumption	<25	E	E	<25	<25

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

Import Sources (2013–16):[5] Canada, 50%; China, 18%; Australia, 14%; Mexico, 7%; and other, 11%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Cadmium oxide	2825.90.7500	Free.
Cadmium sulfide	2830.90.2000	3.1% ad val.
Pigments and preparations based on cadmium compounds	3206.49.6010	3.1% ad val.
Unwrought cadmium and powders	8107.20.0000	Free.
Cadmium waste and scrap	8107.30.0000	Free.
Wrought cadmium and other articles	8107.90.0000	4.4% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

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CADMIUM

Events, Trends, and Issues: Most of the world's primary cadmium metal was produced in Asia, and leading global producers were China, the Republic of Korea, and Japan. A smaller amount of secondary cadmium metal was recovered from recycling NiCd batteries. Although detailed data on the global consumption of primary cadmium were not available, NiCd battery production was thought to have continued to account for the majority of global cadmium consumption. Other end uses for cadmium and cadmium compounds included alloys, anticorrosive coatings, pigments, polyvinyl chloride (PVC) stabilizers, and semiconductors for solar cells.

The average monthly cadmium price began 2017 at $1.49 per kilogram in January and trended upward to $1.72 per kilogram in May. Prices then decreased during the next 3 months, falling to an average of $1.55 per kilogram in August, before increasing to an average of about $2.00 per kilogram in October. News sources attributed the overall increase in price in the first 10 months of 2017 to continued strong demand for cadmium in India, mostly for jewelry alloys. India's net imports of unwrought cadmium and cadmium powders in the first half of 2017 were 2,310 tons, 5% more than those in the first half of 2016 and almost 12 times more than those in the first half of 2013.

World Refinery Production and Reserves:

	Refinery production		Reserves[6]
	2016	2017[e]	
United States[1]	W	W	Quantitative estimates of reserves are not available. The cadmium content of typical zinc ores averages about 0.03%. See the Zinc chapter for zinc reserves.
Canada	2,310	1,700	
China	8,200	8,200	
Japan	1,990	2,200	
Kazakhstan	1,500	1,500	
Korea, Republic of	3,600	3,600	
Mexico	1,190	1,100	
Netherlands	630	630	
Peru	820	780	
Russia	1,300	1,300	
Other countries	2,400	2,400	
World total (rounded)	[7]23,900	[7]23,000	

World Resources: 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. Zinc-bearing coals of the Central United States and Carboniferous age coals of other countries also contain large subeconomic resources of cadmium.

Substitutes: Lithium-ion and nickel-metal hydride batteries can replace NiCd batteries in many applications. Except where the surface characteristics of a coating are critical (for example, fasteners for aircraft), coatings of zinc, zinc-nickel, or vapor-deposited aluminum can be substituted for cadmium in many plating applications. Cerium sulfide is used as a replacement for cadmium pigments, mostly in plastics. Barium-zinc or calcium-zinc stabilizers can replace barium-cadmium stabilizers in flexible PVC applications. Amorphous silicon and copper-indium-gallium-selenide photovoltaic cells compete with cadmium telluride in the thin-film solar-cell market.

[e]Estimated. E Net exporter. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Cadmium metal produced as a byproduct of zinc refining plus metal from recycling.
[2]Less than ½ unit.
[3]Average New York dealer price for 99.95% purity in 5-short-ton lots (2013–15). Source: Platts Metals Week. Average free market price for 99.95% purity in 10-ton lots; cost, insurance, and freight; global ports (2016). Source: Metal Bulletin.
[4]Defined as imports of unwrought metal and metal powders – exports of unwrought metal and metal powders + adjustments for industry stock changes.
[5]Imports for consumption of unwrought metal and metal powders (Harmonized Tariff Schedule code 8107.20.0000).
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]Excludes U.S. production.

CEMENT

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Production of portland cement in 2017 in the United States increased slightly to about 83.5 million tons, and output of masonry cement was stagnant at 2.4 million tons. Cement was produced at 98 plants in 34 States, plus at 2 plants in Puerto Rico. Overall U.S. cement production continued to be well below the record level of 99 million tons reported in 2005, reflecting continued full-time idle status at a few plants, underutilized capacity at most others, production disruptions from plant upgrades, plant closures over the interim, and relatively inexpensive imports in some recent years. Sales of cement increased modestly in 2017. Overall, sales were 31.5 million tons lower than the record volume set in 2005. The overall value of sales was about $12.4 billion. Most of the sales of cement were to make concrete, worth at least $65 billion. In recent years, about 70% to 75% of cement sales have been to ready-mixed concrete producers, 8% to 10% to contractors (mainly road paving; much contractor work also involves ready-mixed concrete), about 10% to concrete product manufacturers, and 7% to 10% to other customer types. Texas, California, Missouri, Florida, and Pennsylvania were, in descending order, the five leading cement-producing States and accounted for nearly 50% of U.S. production.

Salient Statistics—United States:[1]	2013	2014	2015	2016	2017[e]
Production:					
Portland and masonry cement[2]	76,804	82,600	84,405	[e]84,500	85,900
Clinker	69,420	74,372	76,043	75,332	75,300
Shipments to final customers, includes exports	83,187	90,070	93,276	95,179	96,900
Imports of hydraulic cement for consumption	6,289	7,584	10,376	11,742	12,000
Imports of clinker for consumption	806	720	879	1,496	1,200
Exports of hydraulic cement and clinker	1,670	1,397	1,543	1,283	1,100
Consumption, apparent[3]	81,800	89,200	92,100	[e]94,200	96,800
Price, average mill value, dollars per ton	95.00	100.50	106.50	[e]111.00	113.00
Stocks, cement, yearend	6,570	6,140	7,230	[e]8,000	8,000
Employment, mine and mill, number[e]	10,300	10,000	10,000	9,500	9,000
Net import reliance[4] as a percentage of apparent consumption	7	8	11	13	13

Recycling: Cement kiln dust is routinely recycled to the kilns, which also can make use of a variety of waste fuels 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. Cement is not directly recycled, but significant quantities of concrete are recycled for use as construction aggregate.

Import Sources (2013–16):[5] Canada, 41%; Greece, 14%; Republic of Korea, 13%; China, 12%; and other, 20%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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: On a year-on-year basis, monthly sales of cement in 2017 were highly erratic, with an overall increase for the year of less than 2%. Although construction expenditures were higher during the year in the residential and nonresidential sectors, those for public sector construction continued a multiyear decline. Sales for oil well drilling benefitted from higher crude oil prices, especially in Texas. Hurricanes disrupted construction activities (hence cement sales) in several States, especially Texas, Florida, and Puerto Rico; Texas and Florida traditionally rank first and third, respectively, among the States in total cement sales. Production of cement remained well below capacity, with some multikiln plants continuing to rely primarily on a single kiln during the year. Unlike sales growth in 2013–15, when much of the increase was of imported cement, imports were stagnant in 2017 and the growth in sales was largely supplied by higher domestic production. Production remained well below full capacity levels, in part reflecting technical and environmental issues in returning long-idle kilns to full production at some plants.

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CEMENT

The trend of company mergers and individual plant sales that had characterized the previous 2 years continued in 2017. Early in the year, a foreign-owned cement plant in Ohio was sold to a domestic cement company. Later in the year, it was announced that the largest remaining domestically owned cement company would be sold to a European company, with the sale expected to close at yearend or early in 2018. The sale involved eight cement plants, accounting for about 7% of total U.S. production capacity. Shortly after the announcement of this sale, the same European company announced that it would buy a foreign-owned cement plant in northern Florida.

Plant upgrades to precalciner dry kiln technology were completed at one plant in Oklahoma and one in New York. These upgrades, and some others underway, were expected to improve the ability of individual plants to comply with the stringent emissions limits of the 2010 National Emissions Standards for Hazardous Air Pollutants (NESHAP) protocol for cement plants, which went into effect in September 2015. Many plants have installed emissions-reduction technologies to comply with the NESHAP, but it remained unclear if such modifications would be economic at all plants or for all individual kilns (some being of older technology) at multikiln plants. It remained possible that some kilns would be shut down, or used only sparingly, in light of the NESHAP limits, and thus constrain U.S. clinker production capacity.

World Production and Capacity:

	Cement production[e]		Clinker capacity[e]	
	2016	2017	2016	2017
United States (includes Puerto Rico)	85,000	86,300	107,000	109,000
Brazil	57,000	54,000	60,000	60,000
China	2,400,000	2,400,000	2,000,000	2,000,000
Egypt	55,000	58,000	46,000	48,000
India	280,000	270,000	280,000	280,000
Indonesia	63,000	66,000	78,000	78,000
Iran	55,000	56,000	79,000	80,000
Japan	53,300	53,000	53,000	53,000
Korea, Republic of	57,000	59,000	50,000	50,000
Russia	56,000	58,000	80,000	80,000
Saudi Arabia	62,000	63,000	75,000	75,000
Turkey	75,400	77,000	80,000	82,000
Vietnam	77,300	78,000	90,000	90,000
Other countries (rounded)	724,000	750,000	625,000	721,000
World total (rounded)	4,100,000	4,100,000	3,700,000	3,800,000

World Resources: Although reserves at individual plants are subject to exhaustion, limestone and other cement raw materials are geologically widespread and abundant, and overall shortages are unlikely in the future.

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. A number of 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 plus masonry cement unless otherwise noted; excludes Puerto Rico unless otherwise noted.

[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 of cesium oxide unless otherwise noted)

<u>Domestic Production and Use</u>: In 2017, there was no domestic mine production of cesium, and the United States was 100% import reliant for cesium minerals. The United States sourced the majority of its pollucite, the principal cesium mineral, from the largest known deposit in North America at Bernic Lake, Manitoba, Canada; however, that operation ceased mining at the end of 2015 and continued to produce cesium products from stocks.

Cesium minerals are used as feedstocks to produce a variety of cesium compounds and cesium metal. By gross weight, cesium formate brines used for high-pressure, high-temperature well drilling for oil and gas production and exploration are the primary applications for cesium. Cesium nitrate is used as a colorant and oxidizer in the pyrotechnic industry, in petroleum cracking, in scintillation counters, and in x-ray phosphors. Cesium chloride is 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 a repellent in agricultural applications, and in specialty glasses.

Cesium metal is used in the production of cesium compounds and in photoelectric cells. Cesium carbonate is used in the alkylation of organic compounds and in energy conversion devices, such as fuel cells, magneto-hydrodynamic generators, and polymer solar cells. Cesium bromide is used in infrared detectors, optics, photoelectric cells, scintillation counters, and spectrophotometers. Cesium hydroxide is used as an electrolyte in alkaline storage batteries. Cesium iodide is used in fluoroscopy equipment—Fourier Transform Infrared spectrometers—as the input phosphor of x-ray image intensifier tubes, and in scintillators.

Cesium isotopes, which are obtained as a byproduct in nuclear fission or formed from other isotopes, such as barium-131, are used in electronic, medical, and research applications. Cesium isotopes are used as an atomic resonance frequency standard in atomic clocks, playing a vital role in global positioning satellites, Internet and cellular telephone transmissions, and aircraft guidance systems. Cesium clocks monitor the cycles of microwave radiation emitted by cesium's electrons and use these cycles as a time reference. Owing to the high accuracy of the cesium atomic clock, the international definition of 1 second is based on the cesium atom. The U.S. civilian time and frequency standard is based on a cesium fountain clock at the National Institute of Standards and Technology in Boulder, CO. The U.S. military frequency standard, the United States Naval Observatory Time Scale, is based on 48 weighted atomic clocks, including 25 cesium fountain clocks.

A company in Richland, WA, produced a range of cesium-131 medical products for treatment of various cancers. Cesium-137 is widely used in industrial gauges, in mining and geophysical instruments, and for sterilization of food, sewage, and surgical equipment. Cesium isotopes can be used in metallurgy to remove gases and other impurities, and in vacuum tubes.

<u>Salient Statistics—United States</u>: 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. Only a few thousand kilograms of cesium are consumed in the United States every year. The United States is 100% import dependent for its cesium needs. In 2017, one company offered 1-gram ampoules of 99.8% (metal basis) cesium for $61.80 and 99.98% (metal basis) cesium for $76.00, a slight increase and slight decrease, respectively, from those in 2016. The prices that the company offered for 50 grams of 99.9% (metal basis) cesium acetate, cesium bromide, cesium carbonate, and cesium chloride were $113.60, $69.10, $96.80, and $98.60, respectively. The price for a cesium-plasma standard solution (10,000 micrograms per milliliter) was $79.80 for 50 milliliters and $122.00 for 100 milliliters. The price for 25 grams of cesium formate, 98% basis, was $38.70.

<u>Recycling</u>: 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. The formate brines are recycled with an estimated recovery rate of 85%, which can be reprocessed for further use.

<u>Import Sources (2013–16)</u>: Canada is the chief source of pollucite concentrate imported by the United States.

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CESIUM

Tariff:

Item	Number	Normal Trade Relations 12–31–17
Alkali metals, other	2805.19.9000	5.5% ad val.
Chlorides, other	2827.39.9000	3.7% ad val.
Bromides, other	2827.59.5100	3.6% ad val.
Nitrates, other	2834.29.5100	3.5% ad val.
Carbonates, other	2836.99.5000	3.7% ad val.
Cesium-137, other	2844.40.0021	Free

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic cesium occurrences will likely remain uneconomic unless market conditions change. No known human health issues are associated with naturally occurring cesium, and its use has minimal environmental impact. Radioactive isotopes of cesium have been known to cause adverse health effects.

During 2017, projects that were primarily aimed at developing lithium resources were at various stages of development, including the Soris Lithium Project in Namibia and the Jubilee Lake Lithium Prospect in Canada. The projects focused on pegmatite deposits containing pollucite and (or) spodumene, which primarily contain lithium, tantalum, or both, but may also contain minor quantities of cesium and rubidium.

World Mine Production and Reserves: Pollucite, mainly found in association with lithium-rich, lepidolite-bearing or petalite-bearing zoned granite pegmatites, is the principal cesium ore mineral. Cesium reserves are, therefore, estimated based on the occurrence of pollucite, which is mined as a byproduct of the lithium mineral lepidolite. Most pollucite contains 5% to 32% cesium oxide (Cs_2O). Data on cesium resources, other than those listed, are either limited or not available. The main pollucite zone at Bernic Lake in Canada contains approximately 120,000 tons of contained cesium oxide in pollucite ore, with premining average ore grades of 23.3% Cs_2O. Zimbabwe and Namibia produced cesium in small quantities as a byproduct of lithium mining operations. Reserves at the Manitoba, Canada, operation were no longer considered economically recoverable following a mine collapse in 2015.

	Reserves[1]
Namibia	30,000
Zimbabwe	60,000
Other countries	NA
World total (rounded)	90,000

World Resources: World resources of cesium have not been estimated. Cesium is associated with lithium-bearing pegmatites worldwide, and cesium resources have been identified in the United States, Canada, Namibia, and Zimbabwe. In the United States, pollucite occurs in pegmatites in Alaska, Maine, and South Dakota. Lower concentrations are also known in brines in Chile and China and in geothermal systems in Germany, India, and Tibet. China was believed to have cesium-rich deposits of geyserite, lepidolite, and pollucite, with concentrations highest in Yichun, Jiangxi, China, although no resource 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.

NA Not available.
[1]See Appendix C for resource and reserve definitions and information concerning data sources.

CHROMIUM

(Data in thousand metric tons of chromium content unless otherwise noted)

Domestic Production and Use: In 2017, the United States was expected to consume about 6% of world chromite ore production in various forms of imported materials, such as chromite ore, chromium chemicals, chromium ferroalloys, chromium metal, and stainless steel. Imported chromite ore was consumed by one chemical firm to produce chromium chemicals. One company produced chromium metal. Stainless-steel and heat-resisting-steel producers were the leading consumers of ferrochromium. Stainless steels and superalloys require chromium. The value of chromium material consumption in 2016 was $637 million as measured by the value of net imports, excluding stainless steel, and was expected to be about $679 million in 2017.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production:					
Mine	—	—	—	—	—
Recycling[1]	150	157	161	170	160
Imports for consumption	557	683	511	528	600
Exports	240	256	236	253	250
Government stockpile releases	10	15	9	5	7
Consumption:					
Reported (includes recycling)	402	417	413	416	420
Apparent (includes recycling)[2]	477	598	445	451	510
Unit value, average annual import (dollars per ton):					
Chromite ore (gross weight)	309	243	216	198	320
Ferrochromium (chromium content)[3]	2,162	2,208	2,251	1,750	2,600
Chromium metal (gross weight)	11,147	11,002	11,235	9,926	9,500
Stocks, yearend, held by U.S. consumers	8	8	8	8	8
Net import reliance[4] as a percentage of apparent consumption	69	74	64	62	69

Recycling: In 2017, recycled chromium (contained in reported stainless steel scrap receipts) accounted for 31% of apparent consumption.

Import Sources (2013–16): Chromite (mineral): South Africa, 98%; Canada, 2%; and other, <1%. Chromium-containing scrap[5]: Canada, 49%; Mexico, 44%; and other, 7%. Chromium (primary metal)[6]: South Africa, 35%; Kazakhstan, 12%; Russia, 7%; and other, 46%. Total imports: South Africa, 38%; Kazakhstan, 10%; Russia, 6%; and other, 46%.

Tariff:[7] Item	Number	Normal Trade Relations 12–31–17
Chromium ores and concentrates:		
Cr_2O_3 not more than 40%	2610.00.0020	Free.
Cr_2O_3 more than 40% and less than 46%	2610.00.0040	Free.
Cr_2O_3 more than or equal to 46%	2610.00.0060	Free.
Chromium oxides and hydroxides:		
Chromium trioxide	2819.10.0000	3.7% ad val.
Other	2819.90.0000	3.7% ad val.
Sodium dichromate	2841.30.0000	2.4% ad val.
Potassium dichromate	2841.50.1000	1.5% ad val.
Other chromates and dichromates	2841.50.9100	3.1% ad val.
Carbides of chromium	2849.90.2000	4.2% ad val.
Ferrochromium:		
Carbon more than 4%	7202.41.0000	1.9% ad val.
Carbon more than 3%	7202.49.1000	1.9% ad val.
Carbon more than 0.5%	7202.49.5010	3.1% ad val.
Other	7202.49.5090	3.1% ad val.
Ferrosilicon chromium	7202.50.0000	10% ad val.
Chromium metal:		
Unwrought, powder	8112.21.0000	3% ad val.
Waste and scrap	8112.22.0000	Free.
Other	8112.29.0000	3% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

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CHROMIUM

Government Stockpile: For FY 2018, the Defense Logistics Agency (DLA) Strategic Materials announced maximum disposal limits for chromium materials of about 21,300 tons of ferrochromium and 181 tons of chromium metal. No acquisitions were planned.

Stockpile Status—9–30–17[8]

Material[9]	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Ferrochromium:			
High-carbon	50.0	[10]21.3	7.26
Low-carbon	29.1	—	1.64
Chromium metal	3.86	0.181	0.045

Events, Trends, and Issues: Chromium is consumed in the form of ferrochromium to produce stainless steel. China was the leading chromium-consuming and stainless-steel-producing country. South Africa was the leading chromite ore and ferrochromium producer upon which world stainless steel producers depend directly or indirectly for chromium supply, based on production data. Ferrochromium production is electrical-energy intensive, so constrained electrical power supply results in constrained ferrochromium production. The recent commissioning of new ferrochromium furnaces in South Africa and China has the potential to increase ferrochromium production by 630,000 tons per year.

From October 2016 to July 2017, ferrochromium prices increased by 48% for charge grade and 64% for high carbon. This increase was the result of an increase in the demand for stainless steel, particularly in China, and a lack of chromium inventory. Since then, the prices have remained relatively high.

DLA Strategic Materials planned to continue selling ferrochromium in fiscal year 2018 until it reached its limit; however, DLA Strategic Materials would need congressional authority to continue sales into fiscal year 2019.

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

	Mine production[11] 2016	Mine production[11] 2017[e]	Reserves[12] (shipping grade)[13]
United States	—	—	620
India	3,200	3,200	54,000
Kazakhstan	5,380	5,400	230,000
South Africa	14,700	15,000	200,000
Turkey	2,800	2,800	26,000
Other countries	4,160	4,200	NA
World total (rounded)	30,200	31,000	510,000

World Resources: World resources are greater than 12 billion tons of shipping-grade chromite, sufficient to meet conceivable demand for centuries. The world's 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]Recycling production is based on reported receipts of all types of stainless steel scrap.
[2]Defined as production (from mines and recycling) + imports – exports + adjustments for Government and industry stock changes.
[3]Excludes ferrochromium silicon.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]Includes chromium metal scrap and stainless steel scrap.
[6]Includes chromium metal, ferrochromium, and stainless steel.
[7]In addition to the tariff items listed, certain imported chromium materials (see 26 U.S.C. sec. 4661, 4662, and 4672) are subject to excise tax.
[8]See Appendix B for definitions.
[9]Units are thousand tons of material by gross weight.
[10]High-carbon and low-carbon ferrochromium, combined.
[11]Mine production units are thousand tons, gross weight, of marketable chromite ore.
[12]See Appendix C for resource and reserve definitions and information concerning data sources.
[13]Reserves units are thousand tons of shipping-grade chromite ore, which is deposit quantity and grade normalized to 45% Cr_2O_3.

CLAYS

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Production of clays (sold or used) in the United States was estimated to be 24.7 million tons valued at $1.54 billion in 2017, with about 145 companies operating clay and shale mines in 40 States. The leading 20 firms produced approximately 43% of the U.S. tonnage and 70% of the value for all types of clay. Principal uses for specific clays were estimated to be as follows: ball clay—56% floor and wall tile and 17% sanitaryware; bentonite—42% pet waste absorbents and 26% drilling mud; common clay—46% brick, 17% cement, and 31% lightweight aggregate; fire clay—62% refractory products and miscellaneous uses and 38% heavy clay products (for example, brick and cement); fuller's earth—84% pet waste absorbents; and kaolin—32% paper coating and filling, 25% ceramics, and 13% refractories. Lightweight ceramic proppants for use in hydraulic fracturing are also a significant market for kaolin, but available data were insufficient for a reliable estimate of the market size.

The United States accounted for 15% to 25% of the global production of refined clays, excluding common clay and shale. U.S. exports of bentonite increased by an estimated 17% in 2017 relative to the prior year. Canada, Saudi Arabia and Japan (in decreasing order by tonnage) were the leading destinations for United States bentonite and accounted for 66% of exports. Kaolin exports were essentially the same as in 2016. Exports of kaolin went primarily to Japan, China, Mexico, Finland, and Canada (in decreasing order by tonnage).

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production (sold or used):					
Ball clay	1,000	1,030	1,030	941	960
Bentonite	4,350	4,800	4,010	3,600	3,700
Common clay	11,000	11,400	12,200	11,700	12,300
Fire clay	194	222	225	528	530
Fuller's earth[1]	1,990	1,980	1,930	1,680	1,700
Kaolin	6,140	6,250	6,030	5,170	5,500
Total[1, 2]	24,700	25,700	25,400	23,600	24,700
Imports for consumption:					
Artificially activated clays and earths	24	26	24	26	28
Kaolin	467	518	426	389	480
Other	136	47	70	57	76
Total[2]	627	591	520	472	580
Exports:					
Artificially activated clays and earths	160	175	173	143	140
Ball clay	52	33	48	41	84
Bentonite	890	901	938	801	940
Clays, not elsewhere classified	304	282	268	256	240
Fire clay[3]	268	237	217	184	240
Fuller's earth	86	92	77	86	77
Kaolin	2,540	2,640	2,420	2,290	2,300
Total[2]	4,300	4,360	4,140	3,800	4,000
Consumption, apparent[4]	20,900	21,900	21,800	20,300	21,000
Price, ex-works, average, dollars per ton:					
Ball clay	43	44	46	45	46
Bentonite	65	69	74	75	75
Common clay	12	11	13	15	15
Fire clay	18	17	14	13	13
Fuller's earth[1]	88	86	106	93	96
Kaolin	146	144	151	160	160
Employment (excludes office workers):					
Mine (may not include contract workers)	1,130	1,150	1,130	1,120	1,140
Mill	4,820	4,930	4,730	4,440	4,500
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2013–16): All clay types combined: Brazil, 76%; Mexico, 7%; China, 5%; and other, 12%.

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CLAYS

Tariff: Item	Number	Normal Trade Relations 12–31–17
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 val.
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, flower pots, 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: Total sales of U.S. clay increased by 5% in 2017 compared with those in 2016. Increases in construction spending and housing starts led to a 5% growth in sales of common clay, and bentonite sales increased by 3%, driven by increased domestic oil drilling activity. Higher kaolin production was likely a result of increased demand for ceramic proppants used by the oil and gas industry.

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

	Mine production					
	Bentonite		Fuller's earth		Kaolin	
	2016	2017[e]	2016	2017[e]	2016	2017[e]
United States	3,600	3,700	[1]1,680	[1]1,700	5,170	5,500
Brazil (beneficiated)	405	400	—	—	2,100	2,100
China	5,600	5,600	—	—	3,200	3,200
Czechia	369	370	—	—	[7]3,450	[7]3,500
Germany	395	400	—	—	4,300	4,300
Greece	[7]808	[7]800	238	240	—	—
India	802	800	6	6	[7]4,110	[7]4,100
Iran	436	440	—	—	791	790
Mexico	470	470	250	260	320	320
Senegal	—	—	188	190	—	—
Spain	113	110	647	650	[7]330	[7]250
Turkey	3,135	3,100	10	10	1,890	1,900
Ukraine	210	210	—	—	1,820	1,800
United Kingdom	—	—	—	—	1,010	1,000
Other countries	2,700	2,600	275	340	7,000	8,200
World total (rounded)	19,000	19,000	[1]3,290	[1]3,400	35,500	37,000

World Resources: Resources of all clays are extremely large.

Substitutes: Clays compete with calcium carbonate in filler and extender applications; diatomite, organic 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 of cobalt content unless otherwise noted)

Domestic Production and Use: In 2017, a nickel-copper mine in Michigan produced cobalt-bearing nickel concentrate. Most U.S. cobalt supply comprised imports and secondary (scrap) materials. Six companies were known to produce cobalt chemicals. About 45% of the cobalt consumed in the United States was used in superalloys, mainly in aircraft gas turbine engines; 7% in cemented carbides for cutting and wear-resistant applications; 17% in various other metallic applications; and 31% in a variety of chemical applications. The total estimated value of cobalt consumed in 2017 was $575 million.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production:					
Mine[e]	—	120	760	690	650
Secondary	2,160	2,200	2,750	2,750	2,800
Imports for consumption	10,400	11,300	11,400	12,800	12,100
Exports	3,850	4,500	3,830	4,160	5,100
Shipments from Government stockpile excesses[1]	—	—	—	—	—
Consumption:					
Reported (includes secondary)	8,170	8,650	8,830	9,010	8,600
Apparent (includes secondary)[2]	8,660	8,710	10,300	11,500	9,830
Price, average, dollars per pound:					
U.S. spot, cathode[3]	12.89	14.48	13.44	12.01	26.60
London Metal Exchange (LME), cash	12.26	14.00	12.90	11.57	24.70
Stocks, yearend:					
Industry	1,070	1,410	1,320	1,220	1,200
LME, U.S. warehouse	41	9	165	195	185
Net import reliance[4] as a percentage of apparent consumption	75	75	73	76	72

Recycling: In 2017, cobalt contained in purchased scrap represented an estimated 33% of cobalt reported consumption.

Import Sources (2013–16): Cobalt contained in metal, oxide, and salts: Norway, 16%; China, 15%; Japan, 11%; Finland, 9%; and other, 49%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Cobalt ores and concentrates	2605.00.0000	Free.
Chemical compounds:		
Cobalt oxides and hydroxides	2822.00.0000	0.1% ad val.
Cobalt chlorides	2827.39.6000	4.2% ad val.
Cobalt sulfates	2833.29.1000	1.4% ad val.
Cobalt carbonates	2836.99.1000	4.2% ad val.
Cobalt acetates	2915.29.3000	4.2% ad val.
Unwrought cobalt, alloys	8105.20.3000	4.4% ad val.
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 val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9–30–17[5]

Material[6]	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Cobalt	302	—	—
Cobalt alloys (gross weight)	0.271	—	—

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COBALT

Events, Trends, and Issues: Congo (Kinshasa) continued to be the world's leading source of mined cobalt, supplying more than one-half of world cobalt mine production. With the exception of production in Morocco and artisanally mined cobalt in Congo (Kinshasa), most cobalt is mined as a byproduct of copper or nickel. In 2017, average annual cobalt prices more than doubled, owing to strong demand from consumers, limited availability of cobalt on the spot market, and an increase in metal purchases by investors. Growth in world refined cobalt supply was forecast to increase at a lower rate than that of world cobalt consumption, which was driven mainly by strong growth in the rechargeable battery and aerospace industries. As a result, the global cobalt supply was expected to remain limited in the near term. China was the world's leading producer of refined cobalt and a leading supplier of cobalt imports to the United States. Much of China's production was from ore and partially refined cobalt imported from Congo (Kinshasa); scrap and stocks of cobalt materials also contributed to China's supply. China was the world's leading consumer of cobalt, with nearly 80% of its consumption being used by the rechargeable battery industry.

World Mine Production and Reserves: Reserves were revised based on Government or industry reports.

	Mine production		Reserves[7]
	2016	2017[e]	
United States	690	650	23,000
Australia	5,500	5,000	[8]1,200,000
Canada	4,250	4,300	250,000
Congo (Kinshasa)	64,000	64,000	3,500,000
Cuba	4,200	4,200	500,000
Madagascar	3,800	3,800	150,000
New Caledonia[9]	3,390	2,800	—
Papua New Guinea	[7]2,190	3,200	51,000
Philippines	4,100	4,000	280,000
Russia	5,500	5,600	250,000
South Africa	2,300	2,500	29,000
Zambia	3,000	2,900	270,000
Other countries	7,600	5,900	560,000
World total (rounded)	111,000	110,000	7,100,000

World Resources: Identified cobalt resources of the United States are estimated to be about 1 million tons. Most of these resources are in Minnesota, but other important occurrences are in Alaska, California, Idaho, Michigan, Missouri, Montana, Oregon, and Pennsylvania. With the exception of resources in Idaho and Missouri, any future cobalt production from these deposits would be as a byproduct of another metal. Identified world terrestrial cobalt resources are about 25 million tons. The vast majority of these 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 hosted in mafic and ultramafic rocks in Australia, Canada, Russia, and the United States. More than 120 million tons of cobalt resources have been identified in manganese nodules and crusts on the floor of the Atlantic, Indian, and Pacific Oceans.

Substitutes: In some applications, substitution for cobalt would result in a loss in product performance. Potential substitutes include barium or strontium ferrites, neodymium-iron-boron, 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, cermets, or ceramics in cutting and wear-resistant materials; iron-phosphorous, manganese, nickel-cobalt-aluminum, or nickel-cobalt-manganese in lithium-ion batteries; nickel-based alloys or ceramics in jet engines; nickel in petroleum catalysts; and rhodium in hydroformylation catalysts.

[e]Estimated. — Zero.
[1]Cobalt metal. In 2014–17, the Defense Logistics Agency acquired cobalt-bearing battery precursor materials and cobalt alloys.
[2]Defined as net import reliance + secondary production, as estimated from consumption of purchased scrap.
[3]As reported by Platts Metals Week. Cobalt cathode is refined cobalt metal produced by an electrolytic process.
[4]Defined as imports – exports + adjustments for Government and industry stock changes for refined cobalt.
[5]See Appendix B for definitions.
[6]See Lithium for information about cobalt-containing materials for use in lithium-ion batteries.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]For Australia, Joint Ore Reserves Committee-compliant reserves were about 390,000 tons.
[9]Overseas territory of France. Although nickel-cobalt mining and processing continued, the leading producer reported zero reserves owing to recent nickel prices.

COPPER

(Data in thousand metric tons of copper content unless otherwise noted)

Domestic Production and Use: In 2017, U.S. mine production of recoverable copper decreased by 11% to an estimated 1.27 million tons and was valued at an estimated $8 billion, an increase of 13% from $7.09 billion in 2016. Arizona was the leading copper-producing State and was responsible for about 68% of domestic output, followed by Utah, New Mexico, Nevada, Montana, Michigan, and Missouri. Twenty-three mines recovered copper, 16 of which accounted for 99% of production. Three smelters, 3 electrolytic refineries, 4 fire refineries, and 15 electrowinning facilities operated during 2017. Refined copper and scrap were used at about 30 brass mills, 15 rod mills, and 500 foundries and miscellaneous consumers. Copper and copper alloy products were used in building construction, 43%; electrical and electronic products, 19%; transportation equipment, 19%; consumer and general products, 12%; and industrial machinery and equipment, 7%.[1]

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Mine, recoverable	1,250	1,360	1,380	1,430	1,270
Refinery:					
Primary	993	1,050	1,090	1,180	1,090
Secondary	47	46	49	46	40
Copper recovered from old scrap	166	173	166	150	145
Imports for consumption:					
Ores and concentrates	3	([2])	([2])	([2])	13
Refined	734	620	686	708	750
General imports, refined	730	614	664	701	760
Exports:					
Ores and concentrates	348	410	392	331	235
Refined	111	127	86	134	105
Consumption:					
Reported, refined	1,830	1,760	1,810	1,810	1,800
Apparent, unmanufactured[3]	1,760	1,780	1,820	1,880	1,850
Price, average, cents per pound:					
Domestic producer, cathode	339.9	318.1	256.2	224.9	285.0
London Metal Exchange, high-grade	332.3	311.1	249.5	220.6	280.0
Stocks, yearend, refined, held by U.S. producers, consumers, and metal exchanges	259	190	209	223	260
Employment, mine and mill, thousands	12.0	12.1	11.3	10.1	10.5
Net import reliance[4] as a percentage of apparent consumption (refined copper)	34	31	31	29	33

Recycling: Old scrap, converted to refined metal and alloys, provided an estimated 145,000 tons of copper, equivalent to 8% of apparent consumption. Purchased new scrap, derived from fabricating operations, yielded an estimated 715,000 tons of contained copper. Of the total copper recovered from scrap (including aluminum- and nickel-base scrap), brass and wire-rod mills recovered approximately 80%; copper smelters, refiners, and ingot makers, 15%; and miscellaneous manufacturers, foundries, and chemical plants, 5%. Copper in all scrap contributed about 35% of the U.S. copper supply.[5]

Import Sources (2013–16): Unmanufactured copper (blister and anodes; matte, ash, and precipitates; ore and concentrates; refined; unalloyed and alloyed scrap): Chile, 46%; Canada, 30%; Mexico, 16%; and other, 8%. Refined copper accounted for 85% of unmanufactured copper imports.

Tariff: **Item**	**Number**	**Normal Trade Relations[6] 12–31–17**
Copper ores and concentrates, copper content	2603.00.0010	1.7¢/kg on lead content.
Unrefined copper anodes	7402.00.0000	Free.
Refined and alloys, unwrought	7403.00.0000	1.0% ad val.
Copper wire (rod)	7408.11.0000	1.0% or 3.0% ad val.

Depletion Allowance: 15% (Domestic), 14% (Foreign).

Government Stockpile: None.

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COPPER

Events, Trends, and Issues: The International Copper Study Group projected that global refined copper consumption would be approximately 24 million tons in 2017, slightly more than global refined production. Production and consumption of refined copper were expected to rise slightly compared with those in 2016, whereas mine production was estimated to decline slightly owing to supply disruptions at multiple leading copper mines, lower ore grades, and a general lack of new projects and mine expansions.[7]

In the United States, copper output declined at most mines during 2017 as a result of lower ore grades, reduced mining rates early in the year when copper prices were lower, and (or) disruptions caused by poor weather conditions and technical complications. Total U.S. refined production fell by an estimated 8% because of planned smelter maintenance shutdowns and a 6-week suspension of operations at one smelter following a fatal accident.

Through November 2017, the monthly average COMEX spot copper price fluctuated between $2.55 per pound (May) and $3.10 per pound (October). It was projected to average about $2.80 per pound for the full year, an increase of 27% from $2.20 per pound in 2016. This increase was in part attributed to lower global mine production resulting from supply disruptions, depreciation of the United States dollar, and continued copper consumption growth in China.

World Mine Production and Reserves: Reserves for Australia, Chile, China, the United States, and several other countries were revised based on reported company data and (or) information from the Governments of those countries.

	Mine production		Reserves[8]
	2016	2017[e]	
United States	1,430	1,270	45,000
Australia	948	920	[9]88,000
Canada	708	620	11,000
Chile	5,550	5,330	170,000
China	1,900	1,860	27,000
Congo (Kinshasa)	846	850	20,000
Indonesia	727	650	26,000
Mexico	752	755	46,000
Peru	2,350	2,390	81,000
Zambia	763	755	20,000
Other countries	4,160	4,300	260,000
World total (rounded)	20,100	19,700	790,000

World Resources: A 1998 U.S. Geological Survey (USGS) assessment estimated that 550 million tons of copper were contained in identified and undiscovered resources in the United States.[10] A 2014 USGS global assessment of copper deposits indicated that identified resources contained about 2.1 billion tons of copper (porphyry deposits accounted for 1.8 billion tons of those resources), and undiscovered resources contained an estimated 3.5 billion tons.[11]

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

[e]Estimated.
[1]Distribution reported by the Copper Development Association. Some electrical components are included in each end use.
[2]Less than ½ unit.
[3]Defined as primary refined production + copper from old scrap converted to refined metal and alloys + refined imports (general) – refined exports (domestic) ± changes in refined stocks.
[4]Defined as imports – exports ± adjustments for industry stock changes of refined copper.
[5]Copper supply is defined as apparent consumption + copper recovered from new scrap.
[6]No tariff for certain countries owing to special trade agreements. See the Harmonized Tariff Schedule of the United States.
[7]International Copper Study Group, 2017, Copper market forecast 2017/2018: Lisbon, Portugal, International Copper Study Group press release, October 24, 2 p.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.
[9]For Australia, Joint Ore Reserves Committee-compliant reserves were about 24 million tons.
[10]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., https://pubs.er.usgs.gov/publication/cir1178.
[11]Johnson, K.M., Hammarstrom, J.M., Zientek, M.L., and Dicken, C.L., 2014, Estimate of undiscovered copper resources of the world, 2013: U.S. Geological Survey Fact Sheet 2014–3004, 3 p., *http://dx.doi.org/10.3133/fs20143004.*

DIAMOND (INDUSTRIAL)[1]

(Data in million carats unless otherwise noted)

Domestic Production and Use: In 2017, total domestic production of manufactured industrial diamond bort, girt, dust and powder, and stone was estimated to be 125 million carats with a value of $123 million. Domestic output was synthetic grit, powder, and stone. One firm in Ohio and one firm in Pennsylvania accounted for all of the production. At least nine firms produced polycrystalline diamond from diamond powder. Three companies recovered used industrial diamond as one of their principal operations. Total domestic secondary production of industrial diamond bort, grit, dust and powder, and stone was estimated to be 66.4 million carats with a value of $4.08 million. The United States was one of the world's leading markets. 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). Stone cutting and highway building, milling, and repair consumed most of the industrial diamond stone. About 98% of the U.S. industrial diamond market now uses synthetic industrial diamond because its quality can be controlled and its properties can be customized.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Bort, grit, and dust and powder; natural and synthetic:					
Production:					
Manufactured diamond[e]	46	53	40	42	42
Secondary	38.1	43.7	63.5	66.1	66.1
Imports for consumption	728	682	275	216	391
Exports	149	163	140	134	134
Consumption, apparent[2]	663	616	239	190	365
Price, value of imports, dollars per carat	0.11	0.11	0.20	0.23	0.16
Net import reliance[3] as a percentage of apparent consumption	87	84	57	43	70
Stones, natural and synthetic:					
Production:					
Manufactured diamond[e]	63	72	79	83	83
Secondary	0.34	0.52	0.19	0.36	0.36
Imports for consumption	1.94	2.16	1.31	1.37	1.12
Exports	—	—	—	—	—
Sales from Government stockpile excesses	—	—	—	—	—
Consumption, apparent[2]	65.3	74.7	80.5	84.7	84.5
Price, value of imports, dollars per carat	15.50	14.40	17.50	13.60	15.90
Net import reliance[3] as a percentage of apparent consumption	3	3	2	2	1

Recycling: In 2017, the amount of diamond bort, grit, and dust and powder recycled was estimated to be 66.1 million carats with an estimated value of $3.5 million. It was estimated that 360,000 carats of diamond stone was recycled with an estimated value of $540,000.

Import Sources (2013–16): Bort, grit, and dust and powder; natural and synthetic: China, 78%; Ireland, 8%; Russia, 4%; Romania, 4%; and other, 6%. Stones, primarily natural: South Africa, 23%; India, 21%; Botswana, 20%; Ghana, 13%; and other, 23%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Industrial Miners' diamonds, carbonados	7102.21.1010	Free.
Industrial Miners' diamonds, other	7102.21.1020	Free.
Industrial diamonds, simply sawn, cleaved, or bruted	7102.21.3000	Free.
Industrial diamonds, not worked	7102.21.4000	Free.
Grit or dust and powder of natural diamonds, 80 mesh or finer	7105.10.0011	Free.
Grit or dust and powder of natural diamonds, over 80 mesh	7105.10.0015	Free.
Grit or dust and powder of synthetic diamonds, coated with metal	7105.10.0020	Free.
Grit or dust and powder of synthetic diamonds, not coated with metal, 80 mesh or finer	7105.10.0030	Free.
Grit or dust and powder of synthetic diamonds, 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: In 2017, China was the world's leading producer of synthetic industrial diamond, with annual production exceeding 4 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 and exporter 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 coats the cutting edge of saws used to cut cement in highway construction and repair work.

Demand for synthetic diamond grit and powder is expected to remain greater than that for natural diamond material.

The Gahcho Kué Mine in the Northwest Territories, Canada, began commercial production in February 2017. The mine is expected to be one of the world's largest diamond mines, and it is estimated that the mine will produce around 54 million carats of rough diamond over its 12-year lifetime.

World Mine Production and Reserves:[4] Reserves for Australia, Botswana, and Russia were revised based on Government and company information.

	Mine production		Reserves[5]
	2016	2017[e]	
United States	—	—	NA
Australia	14	14	120
Botswana	6	6	90
Congo (Kinshasa)	19	19	150
Russia	18	18	650
South Africa	2	2	70
Zimbabwe	2	2	NA
Other countries	1	1	90
World total (rounded)	62	62	1,200

World Resources: Natural diamond deposits have been discovered in more than 35 countries. Natural diamond accounts for about 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 about 99% of industrial applications.

[e]Estimated. NA Not available. — Zero.
[1]See Gemstones for information on gem quality diamond.
[2]Defined as manufactured diamond production + secondary diamond production + imports – exports.
[3]Defined as imports – exports.
[4]Natural industrial diamond only. Synthetic diamond production far exceeds natural industrial diamond output. Worldwide production of manufactured industrial diamond totaled at least 4.4 billion carats in 2017; the leading producers included Belarus, China, Ireland, Japan, Russia, South Africa, Sweden, and the United States.
[5]See Appendix C for resource and reserve definitions and information concerning data sources.
[6]For Australia, Joint Ore Reserves Committee-compliant reserves were about 67 million carats.

DIATOMITE

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2017, production of diatomite was estimated to be 700,000 tons with an estimated processed value of $200 million, f.o.b. plant. Six companies produced diatomite at 12 mining areas and 9 processing facilities in California, Nevada, Oregon, and Washington. Diatomite is used in filtration, 50%; lightweight aggregates, 30%; fillers, 15%; absorbents, 5%; and other applications, less than 1%, including specialized pharmaceutical and biomedical uses. The unit value of diatomite varied widely in 2017, from approximately $10 per ton when used as a lightweight aggregate in portland cement to more than $1,000 per ton for limited specialty markets, including art supplies, cosmetics, and DNA extraction.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production[1]	782	901	832	686	700
Imports for consumption	1	4	7	8	10
Exports	92	82	75	66	95
Consumption, apparent[2]	691	823	765	628	615
Price, average value, dollars per ton, f.o.b. plant	293	298	291	284	290
Employment, mine and plant, number[e]	750	750	750	750	750
Net import reliance[3] as a percentage of apparent consumption	E	E	E	E	E

Recycling: None.

Import Sources (2013–16): Canada, 72%; Mexico, 13%; Germany, 5%; Japan, 4%; and other, 6%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Siliceous fossil meals, including diatomite	2512.00.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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DIATOMITE

Events, Trends, and Issues: The amount of domestically produced diatomite sold or used by producers in 2017 increased slightly compared with that of 2016. Apparent domestic consumption decreased slightly in 2017 to an estimated 615,000 tons; exports increased by an estimated 44%. The United States remained the leading global consumer. Filtration (including the purification of beer, liquors, and wine and the cleansing of greases and oils) continued to be the leading end use for diatomite, also known as diatomaceous earth. Domestically, diatomite used in the production of cement was the next largest use. An important application for diatomite is the removal of microbial contaminants, such as bacteria, protozoa, and viruses in public water systems. Other applications for diatomite include filtration of human blood plasma, pharmaceutical processing, and use as a nontoxic insecticide.

In 2017, the United States was the leading producer of diatomite, accounting for 23% of total world production, followed by Czechia and Denmark with 15% each, China with 14%, Argentina with 7%, and Peru with 4%. Smaller quantities of diatomite were mined in 23 additional countries.

World Mine Production and Reserves:

	Mine production		Reserves[4]
	2016	2017[e]	
United States[1]	686	700	250,000
Argentina	200	200	NA
China	420	420	110,000
Czechia	450	450	NA
Denmark[5] (processed)	440	440	NA
France	75	75	NA
Japan	100	100	NA
Korea, Republic of	70	70	NA
Mexico	90	90	NA
Peru	120	120	NA
Russia	70	70	NA
Spain	50	50	NA
Turkey	60	60	44,000
Other countries	120	120	NA
World total (rounded)	2,950	3,000	Large

World Resources: 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 continuing 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 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]Includes sales of moler production.

FELDSPAR AND NEPHELINE SYENITE

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: U.S. feldspar production in 2017 had an estimated value of $35.4 million. The three leading companies mined and processed about 75% of production; four other companies supplied the remainder. Producing States were North Carolina, Virginia, California, Idaho, Oklahoma, and South Dakota, in descending order of estimated tonnage. Feldspar processors reported coproduct recovery of mica and silica sand. Nepheline syenite produced in the United States was mostly used in construction applications and is not included in production.

Feldspar is ground to about 20 mesh for glassmaking and to 200 mesh or finer for most ceramic and filler applications. It was estimated that domestically produced feldspar was 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. The estimated 2016 end-use distribution of domestic feldspar and nepheline syenite was glass, about 60%, and ceramic tile, pottery, and other uses, 40%.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production, marketable[1]	550	530	520	470	530
Imports for consumption:					
Feldspar	4	8	120	37	190
Nepheline syenite	491	503	449	572	1,300
Exports, feldspar	18	16	15	6	6
Consumption, apparent[1, 2]					
Feldspar only	540	520	625	501	710
Feldspar and nepheline syenite	1,000	1,000	1,100	1,100	2,000
Price, average value, dollars per ton:					
Feldspar only, marketable production,	73	66	73	69	67
Nepheline syenite, import value	121	127	150	128	100
Employment, mine, preparation plant, and office, number[e]	280	270	270	250	260
Net import reliance[3] as a percentage of apparent consumption:					
Feldspar	E	E	17	6	26
Nepheline syenite	100	100	100	100	100

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 (2013–16): Feldspar: Turkey, 94%; Mexico and Spain, 2% each; and other, 2%. Nepheline syenite: Canada, 100%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–17**
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 2017, domestic production and sales of feldspar increased by more than 10% and the average unit value of sales decreased by 3% from those of 2016, in part in response to increased competition from imported feldspar and nepheline syenite, up by more than 400% and 100%, respectively. A company based in Canada continued development of a feldspar-quartz-kaolin project in Idaho that contained high-grade potassium feldspar. With its first production not yet established, production of about 45,000 tons of potassium feldspar per year is expected during a 25-year mine life. For several years, the operation has produced a low iron and trace element feldspathic sand product from old mine tailings that it has marketed to ceramic tile producers.

Domestic feldspar consumption has been gradually shifting toward glass from ceramics. A growing segment in the glass industry was solar glass, used in the production of solar panels. Glass, including beverage containers (more than one-half of the feldspar consumed by the glass industry), plate glass, and fiberglass insulation for housing and building construction, continued to be the leading end use of feldspar in the United States.

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FELDSPAR AND NEPHELINE SYENITE

In the United States, residential construction, in which feldspar is a raw material commonly used in the manufacture of plate glass, ceramic tiles and sanitaryware, and insulation, increased in the first 9 months of 2017 compared with the same period in 2016; housing starts and completions rose by about 3% and 11%, respectively. Use of feldspar and nepheline syenite from domestic and foreign sources were expected to increase in 2018, in part owing to an increase in construction and refurbishment projects resulting from the destruction of homes, buildings and infrastructure that took place in 2017 during an active hurricane season along the Gulf Coast and the Southeastern States and wildfires in portions of the Western States. Spending on residential and nonresidential construction increased by 11% and 2%, respectively, during the first 9 months of 2017 compared with the same period in 2016.

Imports of nepheline syenite, which may be substituted for feldspar in some glass and more commonly in ceramic tile manufacture applications, doubled in the first 9 months of 2017 compared with the same period in 2016; virtually all nepheline syenite imports came from Canada.

A company based in Canada continued development of its White Mountain high-purity calcium feldspar (anorthosite) deposit in southwestern Greenland. With construction of all necessary facilities under way, the company planned to begin commissioning of the processing plant in the summer of 2018 and to ship products to customers in the latter half of 2018. Owing to the feldspar’s purity and tests, which indicate an alumina recovery of greater than 90%, the company is targeting its product as a replacement for kaolin in the production of electrical-grade glass (E-glass) fiberglass; kaolin and nepheline syenite in the filler market for paints, coatings, and polymers; and bauxite as a primary source of alumina. Additional potential applications include refractories and ceramics, all of which require higher purity feldspar.

World Mine Production and Reserves:[4] Reserves data for Poland were revised based on Government information.

	Mine production		Reserves[5]
	2016	2017[e]	
United States[1]	470	530	NA
Brazil	400	400	320,000
China	3,500	3,500	NA
Czechia	420	420	28,000
Egypt	400	400	1,000,000
India	1,500	1,500	45,000
Iran	1,000	1,000	630,000
Italy	4,000	3,500	NA
Korea, Republic of	600	600	NA
Malaysia	330	330	NA
Poland	600	600	16,000
Spain	600	600	NA
Thailand	1,300	1,300	NA
Turkey	5,500	5,500	240,000
Venezuela	500	500	NA
Other countries	2,500	2,400	NA
World total (rounded)	23,600	23,000	Large

World Resources: 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. E Net exporter. 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.

FLUORSPAR

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2017, 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. The same company also continued development work and stockpiling of ore for future processing at the Klondike II fluorspar mine in Kentucky. Synthetic fluorspar may have been recovered as a byproduct of petroleum alkylation, stainless steel pickling, or uranium processing, but no data were collected from any of these operations. An estimated 44,400 tons of fluorosilicic acid (FSA), equivalent to about 72,200 tons of fluorspar grading 100%, was recovered from five phosphoric acid plants processing phosphate rock. FSA was used primarily in water fluoridation.

U.S. fluorspar consumption was satisfied by imports and small quantities of byproduct synthetic fluorspar. Domestically, production of hydrofluoric acid (HF) in Louisiana and Texas was by far the leading use for acid-grade fluorspar. HF is the primary feedstock for the manufacture of virtually all fluorine-bearing chemicals and is also a key ingredient in the processing of aluminum and uranium. Fluorspar was also used in cement production, in enamels, as a flux in steelmaking, in glass manufacture, in iron and steel casting, and in welding rod coatings.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Finished, all grades	NA	NA	NA	NA	NA
Fluorspar equivalent from phosphate rock	121	114	105	72	72
Imports for consumption:					
Acid grade	512	291	328	328	390
Metallurgical grade	131	123	48	55	71
Total fluorspar imports	643	414	376	383	460
Hydrofluoric acid	119	125	120	126	130
Aluminum fluoride	43	38	32	20	23
Cryolite	19	16	19	16	10
Exports	16	13	14	12	11
Consumption:					
Apparent[1]	548	518	411	371	450
Reported	441	W	W	W	W
Price,[2] acid grade, yearend, dollars per ton:					
Filtercake	350	290–330	260–280	260–280	260–280
Arsenic <5 parts per million	540–550	370–420	280–310	280–310	280–310
Stocks, yearend, consumer and dealer[3]	313	195	[e]146	[e]147	W
Employment, mine, number[e]	6	6	5	4	5
Net import reliance[4] 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 usage. Primary aluminum producers recycle HF and fluorides from smelting operations.

Import Sources (2013–16): Mexico, 71%; China, 8%; South Africa, 8%; Vietnam, 5%; and other, 8%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Metallurgical grade (less than 97% CaF_2)	2529.21.0000	Free.
Acid grade (97% or more 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.
Synthetic cryolite	2826.30.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

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FLUORSPAR

Events, Trends, and Issues: The Kigali amendment to the Montreal protocol, aimed at reducing emissions from fluorinated greenhouse gases, has affected the fluorochemical market globally. It has resulted in new legislation in many countries, which reduces the production and consumption of hydrofluorocarbons. A new refrigerant, hydrofluoroolefin HFO-1234yf, with a low global-warming potential, has been developed as an alternative. A new facility opened in Geismar, LA, specifically for its production.

Prolonged adverse market conditions have affected numerous mining projects. In the past several years, mines in Bulgaria, Kenya, Namibia, and Russia have been put on care-and-maintenance status or permanently closed. However, a mine in Canada officially opened with production expected to begin in late 2017. Additionally, in South Africa, construction began on a mine with production expected to begin in early 2019.

World Mine Production and Reserves: Production estimates for individual countries were made using country or company-specific data whenever available; other estimates were made based on general knowledge of end-use markets. Reserves were updated with data from Government sources for Brazil and China, from Government sources and company-reported information for the United Kingdom, and from company-reported information for Vietnam.

	Mine production		Reserves[5, 6]
	2016	2017[e]	
United States	NA	NA	4,000
Argentina	39	39	NA
Brazil	24	24	640
China	3,800	3,800	41,000
Germany	50	50	NA
Iran	40	40	3,400
Kazakhstan	110	110	NA
Kenya	43	43	5,000
Mexico	988	990	32,000
Mongolia	202	200	22,000
Morocco	70	70	580
South Africa	165	200	41,000
Spain	130	130	6,000
Thailand	42	40	NA
United Kingdom	17	13	4,000
Vietnam	175	200	5,000
Other countries	33	33	110,000
World total (rounded)	5,930	6,000	270,000

World Resources: Identified world fluorspar resources were approximately 500 million tons of contained fluorspar. Additionally, enormous 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 70 billion tons, equivalent to about 5 billion tons of 100% fluorspar equivalent.

Substitutes: FSA is used to produce aluminum fluoride (AlF_3), but because of differing physical properties, AlF_3 produced from FSA is not readily substituted for AlF_3 produced from fluorspar. FSA has been used to produce HF, but this practice has not been widely adopted. Synthetic fluorspar could potentially be recovered by the Department of Energy's two depleted uranium hexafluoride conversion plants in Paducah, KY, and Portsmouth, OH. However, the preferred product is currently aqueous HF rather than 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. W Withheld to avoid disclosing company proprietary data.

[1]Defined as imports – exports + adjustments for industry stock changes for fluorspar only. Adjustments for stocks changes are included for 2013–16 but were no longer available for 2017 and are not included. Excludes fluorspar production withheld to avoid disclosing company proprietary data and fluorspar equivalent of FSA, HF, AlF_3, and cryolite.

[2]Free on board, Tampico, Mexico. Source: Industrial Minerals.

[3]Industry stocks for leading consumers and fluorspar distributors.

[4]Defined as imports – exports + adjustments for industry stock changes for fluorspar only. Adjustments for stocks changes are included for 2013–16 but were no longer available for 2017 and are not included.

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

[6]Measured as 100% calcium fluoride.

GALLIUM

(Data in kilograms of gallium content unless otherwise noted)

Domestic Production and Use: No domestic primary (low-grade, unrefined) gallium has been recovered since 1987. Globally, primary gallium is recovered as a byproduct of processing bauxite and zinc ores. One company in Utah recovered and refined high-purity gallium from imported low-grade primary gallium metal and new scrap. Imports of gallium metal and gallium arsenide (GaAs) wafers were valued at about $5 million and $180 million, respectively. GaAs was used to manufacture integrated circuits (ICs) and optoelectronic devices, which include laser diodes, light-emitting diodes (LEDs), photodetectors, and solar cells. Gallium nitride (GaN) principally was used to manufacture optoelectronic devices. ICs accounted for 70% of domestic gallium consumption and optoelectronic devices accounted for 30%. Approximately 70% of the gallium consumed in the United States was contained in GaAs and GaN wafers. Gallium metal, trimethyl gallium, and triethyl gallium used in the epitaxial layering process to fabricate epiwafers for the production of LEDs and ICs 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:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production, primary	—	—	—	—	—
Imports for consumption:					
Metal	35,400	53,900	28,600	10,500	22,000
Gallium arsenide wafers (gross weight)	714,000	391,000	2,690,000	1,290,000	800,000
Exports	NA	NA	NA	NA	NA
Consumption, reported	37,800	35,800	29,700	18,100	24,000
Price, yearend, dollars per kilogram:					
High-purity, refined[1]	502	363	317	690	445
Low-purity, primary[2]	276	239	188	125	120
Stocks, consumer, yearend	5,470	3,980	3,280	2,720	3,000
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 Utah.

Import Sources (2013–16): China, 33%; Germany, 23%; United Kingdom, 22%; Ukraine, 17%; and other, 5%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Gallium arsenide wafers, doped	2853.90.9010	2.8% ad val.
Gallium arsenide wafers, doped	3818.00.0010	Free.
Gallium metal	8112.92.1000	3.0% ad val.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Events, Trends, and Issues: Imports of gallium metal and GaAs wafers continued to account for all U.S. consumption of gallium. In 2017, gallium metal imports more than doubled from those of 2016. However, owing to U.S.-based gallium consumers opening new facilities in Asia to be closer to the optoelectronics industry in that region, gallium metal imports in 2017 were still 60% lower than those in 2014.

Primary low-grade (99.99%-pure) gallium prices in China increased by about 15% in 2017 owing to China's gallium producers voluntarily suspending production of low-grade gallium throughout most of 2016. Low-grade gallium prices worldwide, however, continued the more than 5-year decline as China's primary low-grade gallium production continued to exceed worldwide consumption. The average monthly price for low-grade gallium in China increased to $135 to $140 per kilogram throughout 2017 from approximately $120 per kilogram in 2016. China's primary low-grade gallium production capacity has expanded to approximately 600 tons per year since 2016 from 140 tons per year in 2010 on the expectations of increases in LED-based backlighting and general lighting demand. China accounted for more than 80% of worldwide low-grade gallium capacity. In 2017, the average price of U.S. imports of high-grade (99.9999%- and 99.99999%-pure) refined gallium decreased by 36% to $445 per kilogram, and the average price of U.S. imports of low-grade gallium decreased by 4% to $120 per kilogram.

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GALLIUM

China's low-grade gallium production increased in 2017 to approximately 300 tons, 20% more than the estimated 250 tons in 2016. Despite the increase in production and prices in China in 2017, low-grade gallium prices were most likely below the operating costs of many producers.

The value of worldwide GaAs device consumption increased slightly to exceed $7.5 billion in 2016 owing to a growing wireless telecommunications infrastructure in Asia; growth of feature-rich, application-intensive, third- and fourth-generation (3G, 4G) "smartphones," which employ up to 10 times the amount of GaAs in standard cellular handsets; and robust use in military radar and communications applications. Cellular telephone applications accounted for approximately 53% of total GaAs device revenue and wireless communications accounted for 27%. Various automotive, consumer, fiber-optic, and military applications accounted for the remaining revenue.

Owing to their large power-handling capabilities, high-switching frequencies, and higher voltage capabilities, GaN-based products, which historically have been used in defense applications, continued to be used in cable television transmission, commercial wireless infrastructure, power electronics, and satellite markets. In 2017, the GaN radio frequency device market was estimated to have increased by 14% from $370 million in 2016, which was a 23% increase from that of 2015.

General lighting was the leading sector among LED applications and was expected to be the major share of the LED market for the rest of the decade. The other main LED sectors include backlighting and automotive lighting, in decreasing order of sales. During 2017, LED manufacturing capacity in Asia increased significantly owing to China's Government-instituted incentives to increase LED production. China accounted for 54% of global LED manufacturing capacity, an increase of 5% from 49% in 2016. The global LED market was valued at $18.5 billion in 2016, an increase of 21% from $15.3 billion in 2015.

World Production and Reserves:[4] In 2017, world low-grade primary gallium production was estimated to be 315 tons—an increase of 15% from 274 tons in 2016. Low-grade primary gallium producers outside of China most likely restricted output owing to a large surplus of primary gallium. China, Japan, the Republic of Korea, Russia, and Ukraine were the leading producers. Germany ceased primary production in 2016. Primary refined high-purity gallium production in 2017 was estimated to be about 180 tons. China, Japan, Slovakia, the United Kingdom, and the United States were the known principal producers of high-purity refined gallium. Gallium was recovered from new scrap in Canada, China, Germany, Japan, the United Kingdom, and the United States. World primary low-grade gallium production capacity in 2017 was estimated to be 730 tons per year; high-purity refinery capacity, 320 tons per year; and secondary capacity, 270 tons per year.

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. Only a portion of the gallium present in bauxite and zinc ores is recoverable, and the factors controlling the recovery are proprietary. Therefore, an estimate of reserves is not possible.

World Resources: 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. Recovery of gallium from these deposits is therefore unlikely. 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 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. GaAs-based ICs are used in many defense-related applications because of their unique properties, and no effective substitutes exist for GaAs in these applications. GaAs in heterojunction bipolar transistors is being replaced in some applications by silicon-germanium.

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

[1]Estimated based on the average values of U.S. imports for 99.9999%- and 99.99999%-pure gallium.

[2]Estimated based on the average values of U.S. imports for 99.99%-pure gallium.

[3]The United States has not produced gallium since 1987 and recovers no gallium from old scrap. All domestic consumption is assumed to originate from imported gallium.

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

GARNET (INDUSTRIAL)[1]

(Data in metric tons of garnet unless otherwise noted)

Domestic Production and Use: Garnet for industrial use was mined in 2017 by four firms—one in Idaho, one in Montana, and two in New York. In 2017, the estimated value of crude garnet production was about $15 million, and refined material sold or used had an estimated value of $28 million. The major end uses of garnet were, in decreasing percentage of consumption, for abrasive blasting, waterjet cutting, water-filtration media, 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:	2013	2014	2015	2016	2017[e]
Production (crude)	50,600	42,100	55,200	56,400	63,000
Production (refined, sold or used)	45,500	37,100	48,700	49,400	55,000
Imports for consumption[e, 2]	148,000	213,000	238,000	149,000	70,000
Exports[e]	14,400	15,400	14,700	13,400	17,000
Consumption, apparent[e, 3]	184,000	240,000	278,000	192,000	120,000
Employment, mine and mill, number[e]	103	99	105	108	120
Net import reliance[4] as a percentage of apparent consumption	72	82	80	71	46

Recycling: Small quantities of garnet reportedly are recycled; however, a new processing plant in Pennsylvania, which recycles garnet, began production in June 2017 The quantity of garnet recycled was not available.

Import Sources (2013–16):[e] Australia, 45%; India, 37%; South Africa, 11%; China, 6%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Emery, natural corundum, natural garnet, and other natural abrasives, crude	2513.20.1000	Free.
Emery, natural corundum, natural garnet, and other natural abrasives, other than crude	2513.20.9000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Compared with 2016, imports in 2017 were estimated to have decreased by 53%, whereas exports in 2017 were estimated to have increased by 27%. The significant decrease in imports of garnet can, at least in part, be attributed to price changes and a supply shortage of garnet. In 2017, the average unit value of garnet imports was $309 per ton, which represents an increase of 54% compared with the average unit value in 2016. In the United States, on the other hand, most domestically produced crude garnet concentrate was priced around $232 per ton.

During 2017, estimated domestic production of crude garnet concentrates increased by 11% compared with production in 2016. U.S. garnet production was estimated to be about 4% of total global garnet production. The 2017 estimated domestic sales or use of refined garnet increased by 12% compared with sales in 2016. Additionally, a new processing plant in Pennsylvania, which recycles garnet, began production in June 2017 and could account for the increase in exports of garnet in 2017 and part of the reduction of imports; the majority of the increased exports were from the Philadelphia customs district and there were zero imports into the Philadelphia customs district in 2017.

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GARNET (INDUSTRIAL)

Estimated U.S. garnet apparent consumption decreased by 38% compared with that of 2016, with the United States consuming about 6% of global garnet production. World production of garnet decreased in 2017 owing to the closure of mines in Australia and a crackdown on illegal mining and port restrictions in India. The crackdown in India resulted in a global supply shortage of garnet in 2017. The reduction in apparent consumption in the United States was due to a drastic reduction in imports from India and Australia, particularly into the New Orleans customs district. It was unclear whether this was due to the supply shortage or reduced demand. As a result of reduced apparent consumption, U.S. net import reliance decreased in 2017, but the United States remained a net importer.

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 other salable mineral products that occur with garnet, such as kyanite, marble, metallic ores, mica minerals, sillimanite, staurolite, or wollastonite. With the increase in price in imported material, domestic production is expected to continue to increase.

World Mine Production and Reserves:

	Mine production		Reserves[5]
	2016	2017[e]	
United States	56,400	63,000	5,000,000
Australia	575,000	400,000	Moderate to Large
China	88,900	100,000	Moderate to Large
India	500,000	200,000	19,000,000
South Africa	271,000	300,000	NA
Other countries	50,000	50,000	6,500,000
World total (rounded)	1,540,000	1,100,000	Moderate to Large

World Resources: 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, serpentinites, and 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, Canada, China, India, and South Africa, where they are mined for foreign and domestic markets; deposits in Russia and Turkey also have been mined in recent years, primarily for internal markets. Additional garnet resources are in Chile, Czechia, Pakistan, Spain, Thailand, and Ukraine; small mining operations have been reported in most of these countries.

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 sacrifices in quality or cost. 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.

[2]It was assumed that 75% of imports under Harmonized Tariff Schedule codes 2513.20.1000 and 2513.20.9000 were industrial garnet.

[3]Defined as crude production + imports – exports.

[4]Defined as imports – exports.

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

GEMSTONES[1]

(Data in million dollars unless otherwise noted)

Domestic Production and Use: The combined value of U.S. natural and synthetic gemstone output in 2017 was an estimated $71 million, a 6% increase compared with that of 2016. Domestic gemstone production included agate, beryl, coral, diamond, garnet, jade, jasper, opal, pearl, quartz, sapphire, shell, topaz, tourmaline, turquoise, and many other gem materials. In decreasing order of production value, Oregon, Arizona, Idaho, Nevada, Colorado, California, Montana, North Carolina, Arkansas, Utah, and Maine produced 92% of U.S. natural gemstones. Synthetic gemstones were manufactured by five firms in North Carolina, California, New York, South Carolina, and Arizona, in decreasing order of production value. Major gemstone uses were carvings, gem and mineral collections, and jewelry. The apparent consumption in the table below is much lower than the actual consumption because the value of exports includes the value of reexports.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production:[2]					
Natural[3]	9.6	9.5	8.5	11.7	13.0
Laboratory-created (synthetic)	56.9	51.0	55.1	54.9	58.0
Imports for consumption	24,700	26,400	25,100	25,200	25,100
Exports, including reexports[4]	19,400	21,300	18,500	19,500	19,000
Consumption, apparent[5]	5,370	5,160	6,660	5,770	6,170
Price	Variable, depending on size, type, and quality				
Employment, mine, number[e]	1,100	1,100	1,100	1,120	1,120
Net import reliance[6] 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 (2013–16 by value): Israel, 36%; India, 34%; Belgium, 16%; South Africa, 4%; and other, 10%. Diamond imports accounted for 90% of the total value of gem imports.

Tariff:

Item	Number	Normal Trade Relations 12–31–17
Coral and similar materials, unworked	0508.00.0000	Free.
Imitation gemstones	3926.90.4000	2.8% ad val.
Pearls, imitation, not strung	7018.10.1000	4.0% ad val.
Pearls, Imitation, glass beads	7018.10.2000	Free.
Pearls, natural, graded, temporarily strung	7101.10.3000	Free.
Pearls, natural, not elsewhere specified or included	7101.10.6000	Free.
Pearls, cultured	7101.21.0000	Free.
Diamond, unworked or sawn	7102.31.0000	Free.
Diamond, ½ carat or less	7102.39.0010	Free.
Diamond, cut, more than ½ carat	7102.39.0050	Free.
Other gemstones, unworked	7103.10.2000	Free.
Other gemstones, other	7103.10.4000	10.5% ad val.
Rubies, cut	7103.91.0010	Free.
Sapphires, cut	7103.91.0020	Free.
Emeralds, cut	7103.91.0030	Free.
Other gemstones, otherwise worked	7103.99.5000	10.5% ad val.
Synthetic gemstones, cut but not set	7104.90.1000	Free.
Synthetic gemstones, other	7104.90.5000	6.4% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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GEMSTONES

Events, Trends, and Issues: In 2017, the U.S. imports for consumption for gem-quality diamonds were estimated to be about $22.6 billion, which was a 3% decrease compared with $23.2 billion in 2016. U.S. imports for consumption for natural, nondiamond gemstones was estimated to be about $2.50 billion, which was a 23% increase compared with $2.0 billion in 2016. The United States accounted for more than 35% of the world's diamond consumption and is expected to continue to dominate global gemstone demand.

Increases in U.S. synthetic gemstone production were the result of a new synthetic diamond manufacturing firm in California reaching full-scale production and having a full year of production. A South Carolina synthetic diamond manufacturing firm added new manufacturing equipment that greatly increased its capacity in 2016, which was in operation for its first full year during 2017.

A Canada-based company was expected to resume mining off the coast of Namibia in 2018. The Ministry of Mines and Energy of Namibia renewed the license for a period of 10 years. Marine diamond production has exceeded land-based diamond mining in Namibia in recent years. In 2016, Namibia produced 1.72 million carats of which only 403,000 carats were produced on land.

World Gem Diamond Mine Production and Reserves:

	Mine production[7]		Reserves[8]
	2016	2017[e]	
United States	([9])	([9])	World reserves of diamond-bearing deposits are substantial. No reserve data are available for other gemstones.
Angola	8,120	8,100	
Australia	280	280	
Botswana	14,400	14,000	
Brazil	184	180	
Canada	13,000	13,000	
Congo (Kinshasa)	4,640	4,600	
Ghana	142	140	
Guinea	90	90	
Guyana	140	140	
Lesotho	342	340	
Namibia	1,720	1,700	
Russia	22,600	23,000	
Sierra Leone	439	440	
South Africa	6,650	6,700	
Tanzania	205	210	
Zimbabwe	210	210	
Other countries	230	230	
World total (rounded)	73,400	73,000	

World Resources: Most diamond-bearing ore bodies have a diamond content that ranges from less than 1 carat per ton to about 6 carats per ton of ore. The major gem 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 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.
[1]Excludes industrial diamond and garnet. See Diamond (Industrial) and Garnet (Industrial).
[2]Estimated minimum production.
[3]Includes production of freshwater shell.
[4]Reexports account for between 67% and 92% of the totals.
[5]Defined as production (natural and synthetic) + imports – exports (including reexports).
[6]Defined as imports – exports and reexports.
[7]Data in thousands of carats of gem diamond.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.
[9]Less than ½ unit.

GERMANIUM

(Data in kilograms of germanium content unless otherwise noted)

Domestic Production and Use: In 2017, zinc concentrates containing germanium were produced at mines in Alaska, Tennessee, and Washington. Germanium-containing concentrates in Alaska and Washington were exported to a refinery in Canada for processing and germanium recovery. A zinc smelter in Clarksville, TN, produced and exported germanium leach concentrates recovered from processing zinc concentrates from the Middle Tennessee Mines, which were temporarily idled in 2015 and restarted during the second quarter of 2017. Germanium in the form of compounds and metal was imported into the United States for further processing by industry. A company in Utah produced germanium wafers for solar cells used in satellites from imported and recycled germanium. A refinery in Oklahoma recovered germanium from industry-generated scrap and produced germanium tetrachloride for the production of fiber optics. The domestic end uses for germanium were, in descending order of quantity consumed, fiber optics, infrared optics, electronics and solar applications, and other uses. The estimated value of germanium consumed in 2017, based on the annual average price, was about $41 million, 23% more than that in 2016.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production, refinery	W	W	W	W	W
Imports for consumption:					
Germanium metal	34,200	23,700	20,100	11,000	11,900
Germanium dioxide[1]	11,400	12,500	14,300	15,200	11,500
Total exports[2]	12,500	12,000	5,000	4,780	2,490
Shipments from Government stockpile excesses	—	[3]3,000	—	—	—
Consumption, estimated	38,000	32,000	34,000	30,000	30,000
Price, annual average, dollars per kilogram:[4]					
Germanium metal	1,778	1,918	1,792	1,087	1,358
Germanium dioxide	1,307	1,291	1,211	831	944
Net import reliance[5] as a percentage of estimated consumption	>75%	>75%	>75%	>50%	>50%

Recycling: Worldwide, about 30% of the total germanium consumed is produced from recycled materials. During the manufacture of most optical devices, more than 60% of the germanium metal used is routinely recycled as new scrap. Germanium scrap is also recovered from the windows in decommissioned tanks and other military vehicles.

Import Sources (2013–16):[6] Germanium metal: China, 61%; Belgium, 24%; Russia, 6%; Germany, 4%; and other, 5%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Germanium oxides and zirconium dioxide	2825.60.0000	3.7% ad val.
Metal, unwrought	8112.92.6000	2.6% ad val.
Metal, powder	8112.92.6500	4.4% ad val.
Metal, wrought	8112.99.1000	4.4% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: The Defense Logistics Agency (DLA) Strategic Materials Annual Materials Plan for 2017 allocated 5,000 kilograms of germanium metal for potential upgrade/disposal and included a ceiling acquisition of 1,000 kilograms of germanium metal. In fiscal year 2015, the DLA started a program to recover germanium scrap from end-of-life U.S. Army components and had recovered 1,843 kilograms of germanium scrap by the end of September 2017. As of October 2017, 101,939 germanium epitaxial wafers were held for the stockpile at private warehouses.

Stockpile Status—9–30–17[7]

Material	**Inventory**	**Disposal Plan FY 2017**	**Disposals FY 2017**
Germanium metal	13,364	5,000	—

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GERMANIUM

Events, Trends, and Issues: In 2017, estimated domestic consumption of germanium was essentially unchanged from that in 2016. The global end uses for germanium were fiber-optic systems, infrared optics, electronics and solar applications, polymerization catalysts, and other uses (such as phosphors, metallurgy, and chemotherapy). Germanium-containing infrared optics were primarily for military use, but the demand for thermal-imaging devices that use germanium lenses increased during the past few years.

Germanium dioxide and germanium metal prices trended downward from the beginning of 2016 through the end of February 2017 and then gradually increased from March through September 2017. The prices of germanium dioxide and germanium metal increased by 28% and 39%, respectively, during the first 9 months of 2017. Sources attributed the price increases to a recovery in the germanium market following a period of low prices in 2016 after the collapse of the Fanya Metal Exchange Co. Ltd. the prior year. In 2017, significant quantities of germanium stocks reportedly were held in China. China's State Reserve Bureau held 30 metric tons and was expected to continue to stockpile germanium during the next several years.

In 2017, China remained the leading global producer of germanium. Germanium producers in China continued to integrate with downstream operations in order to sell more value-added germanium products. In 2017, China's production was expected to be higher than that of 2016. However, China's germanium production growth rate in the next several years may be negatively affected by the implementation of stricter environmental standards. Germanium's use in fiber optics, infrared, and photovoltaic products increased in China from 2012 through 2017. Production of germanium tetrachloride for fiber optics increased in China in 2017 owing to an additional production line commissioned with one of the country's top germanium producers.

In 2017, the operator of a leading zinc smelter in Australia continued to upgrade production capacity at its smelter in Hobart, Tasmania. The upgrades included construction of a side-leach plant that would enable the smelter to split base metals from minor metals and produce indium and germanium concentrates. The company expected to open the new facility by yearend 2018.

World Refinery Production and Reserves:

	Refinery production[e]		Reserves[8]
	2016	2017	
United States	W	W	Data on the recoverable germanium content of zinc ores are not available.
China	80,000	88,000	
Russia	6,000	6,000	
Other countries[9]	40,000	40,000	
World total[10]	126,000	134,000	

World Resources: The available resources of germanium are associated with certain zinc and lead-zinc-copper sulfide ores. Substantial U.S. reserves of recoverable germanium are contained in zinc deposits in Alaska and Tennessee. Based on an analysis of zinc concentrates, U.S. reserves of zinc may contain as much as 2,500 tons of germanium. Because zinc concentrates are shipped globally and blended at smelters, however, the recoverable germanium in zinc reserves cannot be determined. On a global scale, as little as 3% of the germanium contained in zinc concentrates is recovered. Significant amounts of germanium are contained in ash and flue dust generated in the combustion of certain coals for power generation.

Substitutes: Silicon can be a less-expensive 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. Zinc selenide and germanium glass substitute for germanium metal in infrared applications systems, but often at the expense of performance. Antimony and titanium are substitutes for use as polymerization catalysts.

[e]Estimated. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Data have been adjusted to exclude low value shipments, then multiplied by 69% to account for germanium content.
[2]Includes Schedule B numbers: 8112.92.6100, 8112.99.1000, and 2825.60.0000. Data have been adjusted to exclude low-value shipments. Oxide data have been multiplied by 69% to account for germanium content.
[3]Germanium metal from the National Defense Stockpile that was upgraded to epitaxial wafers.
[4]Average Europe price for minimum 99.99% purity. Source: Argus Media group-Argus Metals International.
[5]Defined as imports – exports + adjustments for Government stock changes.
[6]Import sources are based on gross weight of wrought and unwrought germanium metal and germanium metal powders.
[7]See Appendix B for definitions.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.
[9]Includes Belgium, Canada, Finland, Germany, Japan, and others.
[10]Excludes U.S. production.

GOLD

(Data in metric tons[1] of gold content unless otherwise noted)

Domestic Production and Use: In 2017, domestic gold mine production was estimated to be about 245 tons, 10% more than that in 2016, and the value was estimated to be about $9.9 billion. Gold was produced at more than 40 lode mines, at several large placer mines in Alaska, and numerous smaller placer mines (mostly in Alaska and in the Western States). About 6% of domestic gold was recovered as a byproduct of processing domestic base-metal ores, chiefly copper ores. The top 26 operations yielded more than 99% of the mined gold produced in the United States. Commercial-grade gold was produced at about 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. Estimated domestic uses (excluding gold bullion bar) were jewelry, 38%; electrical and electronics, 34%; official coins, 22%; and other, 6%.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Mine	230	210	214	222	245
Refinery:					
Primary	223	253	248	248	250
Secondary (new and old scrap)	210	135	124	123	120
Imports for consumption[2]	315	308	265	374	240
Exports[2]	686	492	478	393	480
Consumption, reported	160	152	165	171	170
Stocks, yearend, Treasury[3]	8,140	8,140	8,140	8,140	8,140
Price, dollars per troy ounce[4]	1,415	1,269	1,163	1,252	1,260
Employment, mine and mill, number[5]	12,500	12,000	11,900	11,900	12,000
Net import reliance[6] as a percentage of apparent consumption	E	E	E	E	E

Recycling: In 2017, an estimated 120 tons of new and old scrap was recycled, about 70% of reported industrial consumption. The domestic supply of gold from recycling decreased slightly compared with 2016.

Import Sources (2013–16):[2] Canada, 23%; Mexico, 23%; Colombia, 12%; Peru, 11%; and other, 31%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–17**
Precious metal ore and concentrates	2616.10.0000	0.8¢/kg on lead content.
Precious metal ore and concentrates	2616.90.0000	1.7¢/kg on lead content.
Gold bullion	7108.12.1010	Free.
Gold dore	7108.12.1020	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 2017 was slightly more than the price in 2016 and was 25% lower than the record-high annual price in 2012. The Engelhard daily price of gold in 2017 fluctuated through several cycles. The gold price began the year at the lowest level of the year and trended upward through the end of May before decreasing in June and part of July. The price then increased to the year-to-date high (and projected annual high) of $1,351.44 per troy ounce on September 8, because of geopolitical tension in North Korea which spurred investors to purchase more gold. The price trended downward for the rest of September and into early October but was relatively flat for rest of October and November.

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GOLD

The 10% increase in domestic mine production in 2017 was attributed to increases in production from the Cortez Mine in Nevada and the Cresson Mine in Colorado, owing to increased average ore grades and ore placement and recoveries, respectively, and to the recent startup of two new mines. The Haile Mine in South Carolina opened in January 2017 and was the first gold mine east of the Mississippi River since 1999. The Long Canyon Mine in Nevada started up in late 2016. In 2017, worldwide gold production was estimated to have increased slightly from that in 2016. New mine production in Australia and Canada more than offset decreased gold mine production in China owing to increased environmental regulations.

In the first 9 months of 2017, domestic consumption of gold used in the production of coins and bars decreased by more than 50%; however, gold consumption for jewelry increased slightly owing to improved economic conditions. Globally, gold consumption by the jewelry industry increased slightly and for gold coins and bars increased by 13% compared with that in the first 9 months of 2016 because of increased consumption of these items in China and Turkey. However, investments in gold-based exchange-traded funds (ETFs) were significantly lower in the United States and the world during the same period.

World Mine Production and Reserves: Reserves for Australia, Canada, Ghana, Indonesia, Papua New Guinea, Peru, Russia, and Uzbekistan were revised based on Government or industry reports.

	Mine production		Reserves[7]
	2016	2017[e]	
United States	222	245	3,000
Australia	290	300	[8]9,800
Brazil	85	85	2,400
Canada	165	180	2,200
China	453	440	2,000
Ghana	79	80	1,000
Indonesia	80	80	2,500
Kazakhstan	69	70	1,000
Mexico	111	110	1,400
Papua New Guinea	62	60	1,300
Peru	153	155	2,300
Russia	253	255	5,500
South Africa	145	145	6,000
Uzbekistan	102	100	1,800
Other countries	840	845	12,000
World total (rounded)	3,110	3,150	54,000

World Resources: An assessment of U.S. gold resources indicated 33,000 tons of gold in identified (15,000 tons) and undiscovered (18,000 tons) resources.[9] 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 in electrical and electronic products, and in jewelry to economize on gold; 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.

[1]One metric ton (1,000 kilograms) = 32,150.7 troy ounces.

[2]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 in Exchange Stabilization Fund. Stocks were valued at the official price of $42.22 per troy ounce.

[4]Engelhard's average gold price quotation for the year. In 2017, the price was estimated by the U.S. Geological Survey based on data from January through October.

[5]Data from 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]For Australia, Joint Ore Reserves Committee-compliant reserves were about 3,800 tons.

[9]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 thousand metric tons unless otherwise noted)

Domestic Production and Use: Although natural graphite was not produced in the United States in 2017, approximately 95 U.S. firms, primarily in the Great Lakes and Northeastern regions and Alabama and Tennessee, consumed 24,000 tons valued at $42.9 million. The major uses of natural graphite in 2017 were brake linings, lubricants, powdered metals, refractory applications, and steelmaking. During 2017, U.S. natural graphite imports were 50,000 tons, which were 75% flake and high-purity, 24% amorphous, and 1% lump and chip graphite.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, mine	—	—	—	—	—
Imports for consumption	61	70	47	39	50
Exports	10	12	12	14	26
Consumption, apparent[1]	51	57	35	25	24
Price, imports (average dollars per ton at foreign ports):					
Flake	1,330	1,270	1,710	1,460	1,400
Lump and chip (Sri Lankan)	1,720	1,870	1,800	1,880	1,840
Amorphous	375	360	454	509	392
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 led the way in the recycling of graphite products. The market for recycled refractory graphite material is expanding, with material being recycled into products such as brake linings and thermal insulation.

Recovering high-quality flake graphite from steelmaking kish is technically feasible, but not practiced at the present time. 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 (2013–16): China, 35%; Mexico, 31%; Canada, 17%; Brazil, 8%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Crystalline flake (not including flake dust)	2504.10.1000	Free.
Powder	2504.10.5000	Free.
Other	2504.90.0000	Free.

Depletion Allowance: 22% (Domestic lump and amorphous), 14% (Domestic flake), and 14% (Foreign).

Government Stockpile: None.

Events, Trends, and Issues: Worldwide consumption of graphite steadily increased since 2013 and into 2017. This increase resulted from the improvement of global economic conditions and its impact on industries that use graphite; however, U.S. consumption of natural graphite has declined since 2014.

In 2017, principal U.S. import sources of natural graphite were, in descending order of tonnage, China, Mexico, Canada, Brazil, and Madagascar, which combined accounted for 99% of the tonnage and 94% of the value of total imports. Mexico provided all the amorphous graphite, and Sri Lanka provided all the lump and chip dust variety. China, Canada, Brazil, and Madagascar were, in descending order of tonnage, the major suppliers of crystalline flake and flake dust graphite.

During 2017, China produced 67% of the world's graphite. Approximately 70% of production in China is amorphous graphite and about 30% is flake. China does produce some large flake graphite, but the majority of its flake graphite production is very small, in the +200 mesh range.

Graphite production decreased in Madagascar and increased in Mexico and North Korea from that of 2016. New deposits are being developed in Madagascar, Mozambique, Namibia, and Tanzania, and mines are projected to begin production in the near future. During 2017, some of the mines in Mozambique and Tanzania began producing graphite.

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GRAPHITE (NATURAL)

North America produced only 3% of the world's graphite supply with production in Canada and Mexico. No production of natural graphite was reported in the United States, but two companies were developing graphite projects in the United States. Alabama Graphite Corp. was developing the Coosa Graphite Project in Alabama, and Graphite One Resources Inc. was developing the Graphite Creek Project in Alaska.

One U.S. automaker was building a large plant to manufacture lithium-ion electric vehicle batteries. The plant's completion was originally projected for 2020, but the project is about 2 years ahead of schedule. During July 2016, one-sixth of the plant was completed, and the first batteries were produced in January 2017. When the plant is complete, it will require 93,000 tons of flake graphite to produce 35,200 tons of spherical graphite for use as anode material for lithium-ion batteries.

Advances in thermal technology and acid-leaching techniques that enable the production of higher purity graphite powders are likely to lead to development of new applications for graphite in high-technology fields. Such innovative refining techniques have enabled the use of improved graphite in carbon-graphite composites, electronics, foils, friction materials, and specialty lubricant applications. Flexible graphite product lines, such as graphoil (a thin graphite cloth), are likely to be the fastest growing market. Large-scale fuel-cell applications are being developed that could consume as much graphite as all other uses combined.

World Mine Production and Reserves: The reserves data for Brazil, Mozambique, and Tanzania were revised based on information reported by graphite-producing companies and the Governments of those countries.

	Mine production		Reserves[2]
	2016	2017[e]	
United States	—	—	([3])
Brazil	95	95	70,000
Canada	30	30	([3])
China	780	780	55,000
India	149	150	8,000
Korea, North	6	6	([3])
Madagascar	8	7	1,600
Mexico	4	4	3,100
Mozambique	—	23	17,000
Norway	8	8	([3])
Pakistan	14	14	([3])
Russia	19	19	([3])
Sri Lanka	4	4	([3])
Tanzania	—	—	17,000
Turkey	4	4	90,000
Ukraine	15	15	([3])
Vietnam	5	5	([3])
Zimbabwe	6	6	([3])
Other	2	2	([3])
World total (rounded)	1,150	1,200	270,000

World Resources: Domestic resources of graphite are relatively small, but the rest of the world's inferred 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]See Appendix C for resource and reserve definitions and information concerning data sources.

[3]Included with "World total."

GYPSUM

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2017, domestic mine production of crude gypsum was estimated to be 17.5 million tons with a value of about $144 million. The leading crude gypsum-producing States were, in descending order, Nevada, Oklahoma, Texas, Kansas, Iowa, and Colorado, which together accounted for 66% of total mine output. Overall, 47 companies produced or processed gypsum in the United States at 50 mines in 16 States. Approximately 400 synthetic gypsum producers synthesized an estimated 32 million tons of flue-gas desulfurization (FGD) gypsum in 2017. Of the total quantity of FGD gypsum produced, approximately one-half is used in gypsum end-use products, most of which is wallboard. The vast majority of domestic consumption, which totaled approximately 38.3 million tons, was accounted for by manufacturers of wallboard and plaster products. An estimated 7.2 million tons of gypsum was used in cement production and in agricultural applications. Small quantities of high-purity gypsum, used in a wide range of industrial processes, accounted for the remaining tonnage. At the beginning of 2017, the production capacity of operating wallboard plants in the United States was about 33.4 billion square feet[1] per year. Total wallboard sales were estimated to be 25.0 billion square feet.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Crude[2]	15,700	16,200	16,600	17,000	17,500
Synthetic[3]	10,800	15,200	16,000	16,500	16,000
Calcined[4]	15,200	15,300	15,600	17,100	17,500
Wallboard products sold (million square feet[1])	21,800	21,500	22,100	24,700	25,000
Imports, crude, including anhydrite	3,290	3,720	4,030	4,340	4,800
Exports, crude, not ground or calcined	142	67	63	42	34
Consumption, apparent[5]	29,700	35,000	36,500	37,800	38,300
Price:					
Average crude, f.o.b. mine, dollars per metric ton	7.50	8.00	7.80	8.00	8.20
Average calcined, f.o.b. plant, dollars per metric ton	25.00	27.00	28.00	30.00	31.00
Employment, mine and calcining plant, number[e]	4,500	4,500	4,500	4,500	4,500
Net import reliance[6] as a percentage of apparent consumption	12	11	11	11	12

Recycling: Approximately 700,000 tons of gypsum scrap was generated by wallboard manufacturing and 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 (2013–16): Mexico, 42%; Canada, 30%; Spain, 27%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Gypsum; anhydrite	2520.10.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: U.S. gypsum production and apparent consumption increased slightly compared with those of 2016. The world's leading gypsum producer, China, produced more than seven times the amount produced in the United States, the second-ranked gypsum producer. Iran, ranked third in world production, supplied much of the gypsum needed for construction in the Middle East. Spain, the leading producer in Europe, ranked seventh in the world and supplied crude gypsum and gypsum products to much of Western Europe. Increased use of wallboard in Asia, coupled with new gypsum product plants, spurred increased production in that region. As wallboard becomes more widely used in other regions and as environmental regulations for FGD expand at coal-fired powerplants, worldwide production of gypsum is expected to increase.

Demand for gypsum depends principally on the strength of the construction industry, particularly in the United States where the majority of gypsum consumed is used for building plasters, the manufacture of portland cement, and wallboard products. If the construction of wallboard manufacturing plants designed to use synthetic gypsum from

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GYPSUM

FGD units as feedstock continues, this could result in less mining of natural gypsum. The availability of inexpensive natural gas, however, may limit the additional construction of FGD units and, therefore, the use of synthetic gypsum in wallboard. Gypsum imports increased by 11% compared with those of 2016. Exports, although very low compared to imports and often subject to wide fluctuations, decreased by 19%.

World Mine Production and Reserves: Reserves for Brazil, Turkey, and the United Kingdom were revised based on Government and industry information.

	Mine production		Reserves[7]
	2016	2017[e]	
United States	17,000	17,500	700,000
Algeria	2,130	2,100	NA
Argentina	1,500	1,500	NA
Australia	2,580	2,600	NA
Brazil	3,400	3,400	400,000
Canada	1,630	1,600	450,000
China	130,000	130,000	NA
Egypt	2,200	2,200	NA
France	3,280	3,300	NA
Germany	1,800	1,800	NA
India	3,500	3,500	39,000
Iran	16,000	16,000	1,600
Italy	8,550	8,600	NA
Japan	4,670	4,700	NA
Mexico	5,380	5,400	NA
Oman	6,050	6,000	4,900
Pakistan	1,660	1,700	NA
Russia	4,400	4,400	NA
Saudi Arabia	1,860	1,900	NA
Spain	7,000	7,000	NA
Thailand	11,300	11,000	NA
Turkey	9,000	9,000	170,000
United Kingdom	1,200	1,200	30,000
Other countries	15,000	15,000	NA
World total (rounded)	261,000	260,000	Large

World Resources: 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 U.S. western seaboard. Large gypsum deposits occur in the Great Lakes region, the midcontinent region, and several Western States. Foreign resources are large and widely distributed; 81 countries produced gypsum in 2017.

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 FGD 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 2017, synthetic gypsum accounted for approximately 50% 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 9.29×10^{-2} to convert to square meters. Source: The Gypsum Association.

[2]Crude production was revised for 2013–16 to account for the previously underreported quantity of gypsum used in the production of cement.

[3]Data refer to the quantity sold or used, not produced.

[4]From domestic crude and synthetic.

[5]Defined as crude production + total synthetic reported used + imports – exports.

[6]Defined as imports – exports.

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

HELIUM

(Data in million cubic meters of contained helium gas[1] unless otherwise noted)

Domestic Production and Use: The estimated value of Grade-A helium (99.997% or greater) extracted during 2017 by private industry was about $660 million. Fourteen plants (one in Arizona, two in Colorado, five in Kansas, one in Oklahoma, four in Texas, and one in Utah) extracted helium from natural gas and produced crude helium that ranged from 50% to 99% helium. One plant in Colorado and another in Wyoming extracted helium from natural gas and produced Grade-A helium. Three plants 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 2017, estimated domestic consumption of Grade-A helium was 43 million cubic meters (1.5 billion cubic feet), and it was used for magnetic resonance imaging, 30%; lifting gas, 17%; analytical and laboratory applications, 14%; welding, 9%; engineering and scientific applications, 6%; leak detection and semiconductor manufacturing, 5% each; and various other minor applications, 14%.

Salient Statistics—United States:	2013	2014	2015[r]	2016	2017[e]
Helium extracted from natural gas[2]	69	75	71	66	63
Withdrawn from storage[3]	49	27	20	23	28
Grade-A helium sales	118	102	91	89	91
Imports for consumption	2	7	16	24	21
Exports[4]	81	67	65	61	69
Consumption, apparent[4]	39	42	42	52	43
Net import reliance[5] as a percentage of apparent consumption	E	E	E	E	E

In fiscal year (FY) 2017, the price for crude helium to Government users was $2.99 per cubic meter ($83.00 per thousand cubic feet) and to nongovernment users was $3.86 per cubic meter ($107.00 per thousand cubic feet). The price for the Government-owned helium is mandated by the Helium Stewardship Act of 2013 (Public Law 113–40) and determined through public auctions and industry surveys. The estimated price for private industry's Grade-A helium was about $7.21 per cubic meter ($200 per thousand cubic feet), with some 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 practiced more often.

Import Sources (2013–16): Qatar, 95%; and other, 5%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Helium	2804.29.0010	3.7% ad val.

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

Government Stockpile: Under the Helium Stewardship Act of 2013, the BLM manages the Federal Helium Program, which includes all operations of the Cliffside Field helium storage reservoir, in Potter County, TX, and the Government's crude helium pipeline system. Private firms that sell Grade-A helium to Federal agencies are required to purchase a like amount of (in-kind) crude helium from the BLM. The law mandated that the BLM annually sell at auction Federal Conservation helium stored in Bush Dome at the Cliffside Field. The amounts sold are approximately equal to the amount that the Federal helium system can produce each year. The BLM will dispose of all helium-related assets when the remaining conservation helium falls below 83.2 million cubic meters or no later than 2021.
In FY 2017, privately owned companies purchased about 3.9 million cubic meters (142 million cubic feet) of in-kind crude helium. Privately owned companies also purchased 47.8 million cubic meters (1.725 billion cubic feet) of open market sales helium. During FY 2017, the BLM's Amarillo Field Office, Helium Operations, accepted about 6.1 million cubic meters (220 million cubic feet) of private helium for storage and redelivered nearly 33.4 million cubic meters (1.2 billion cubic feet). As of September 30, 2017, about 102.6 million cubic meters (3.7 billion cubic feet) of privately owned helium remained in storage at Cliffside Field.

Stockpile Status—9–30–17[6]

Material	Inventory	Authorized for disposal	Disposal plan FY 2017	Disposals FY 2017
Helium	181.1	181.1	28.4	29.1

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HELIUM

Events, Trends, and Issues: In 2017, the BLM continued implementation of the Helium Stewardship Act of 2013 by conducting its fourth auction of helium from Federal helium storage at the Cliffside Field near Amarillo. By the end of the decade, international helium extraction facilities are likely to become the main source of supply for world helium users. Seven international helium plants are in operation and more are planned during the next 3 to 5 years. Expansions to facilities have been completed in Algeria and Qatar. In 2017, domestic consumption of helium decreased while worldwide consumption remained unchanged; however, an embargo of products from Qatar, beginning about July 2017, caused a temporary shortage. As a result, production of helium from the Federal Helium Reserve increased along with exports.

World Production and Reserves:[8]

	Production		Reserves[9]
	2016	2017[e]	
United States (extracted from natural gas)	66	63	3,900
United States (from Cliffside Field)	23	28	([10])
Algeria	10	14	1,800
Australia	4	4	NA
Canada	<1	<1	NA
China	NA	NA	NA
Poland	2	2	25
Qatar	50	45	NA
Russia	3	3	1,700
World total (rounded)	160	160	NA

World Resources: Section 16 of Public Law 113-40 requires the U.S. Geological Survey (USGS) to complete a national helium gas assessment along with a global helium gas assessment. The USGS and the BLM have been coordinating efforts to complete this assessment. However, it may be several years before a project of this magnitude will be completed. The BLM plans to update the report of Helium Resources of the United States by yearend 2018. Until then, the following estimates are still the best available.

As of December 31, 2006, the total helium reserves and resources of the United States were estimated to be 20.6 billion cubic meters (744 billion cubic feet). This includes 4.25 billion cubic meters (153 billion cubic feet) of measured reserves, 5.33 billion cubic meters (192 billion cubic feet) of probable resources, 5.93 billion cubic meters (214 billion cubic feet) of possible resources, and 5.11 billion cubic meters (184 billion cubic feet) of speculative resources. Included in the measured reserves are 670 million cubic meters (24.2 billion cubic feet) of helium stored in the Cliffside Field Government Reserve, and 65 million cubic meters (2.3 billion cubic feet) of helium contained in Cliffside Field native gas. The Hugoton (Kansas, Oklahoma, and Texas), Panhandle West, Panoma, Riley Ridge in Wyoming, and Cliffside Fields are the depleting fields from which most U.S.-produced helium is extracted. These fields contained an estimated 3.9 billion cubic meters (140 billion cubic feet) of helium.

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. As of December 31, 2017, the BLM had analyzed about 22,100 gas samples from 26 countries and the United States, in a program to identify world helium resources.

Substitutes: There is no substitute for helium in cryogenic applications if temperatures below –429 °F are required. Argon can be substituted for helium in welding, and hydrogen can be substituted for helium in some lighter-than-air applications in which the flammable nature of hydrogen is not objectionable. Hydrogen is also being investigated as a substitute for helium in deep-sea diving applications below 1,000 feet.

[e]Estimated. E Net exporter. NA Not available.
[1]Measured at 101.325 kilopascals absolute (14.696 psia) and 15 °C; 27.737 cubic meters of helium = 1,000 cubic feet of helium at 70 °F and 14.7 psia.
[2]Both Grade-A and crude helium.
[3]Extracted from natural gas in prior years.
[4]Grade-A helium. Defined as Grade-A helium sales + imports – exports.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.
[6]See Appendix B for definitions.
[7]Team Leader, Resources and Evaluation Group, Bureau of Land Management, Amarillo Field Office, Helium Operations, Amarillo, TX.
[8]Production and reserves outside of the United States are estimated.
[9]See Appendix C for resource and reserve definitions and information concerning data sources.
[10]Included in United States (extracted from natural gas) reserves.

INDIUM

(Data in metric tons of indium content unless otherwise noted)

Domestic Production and Use: Indium was not recovered from ores in the United States in 2017. 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 of global indium consumption. ITO thin-film coatings were primarily used for electrical 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. Based on an average of recent annual import levels, estimated domestic consumption of refined indium was 120 tons in 2017. The estimated value of refined indium consumed domestically in 2017, based on the average free market price, was about $26 million.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, refinery	—	—	—	—	—
Imports for consumption	97	123	140	160	120
Exports	NA	NA	NA	NA	NA
Consumption, estimated[1]	97	123	140	160	120
Price, annual average, dollars per kilogram:					
New York dealer[2]	570	705	520	345	360
Free market[3]	NA	NA	410	240	205
Net import reliance[4] 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. A significant quantity of new scrap was recycled domestically; however, data on the quantity of secondary indium recovered from scrap were not available.

Import Sources (2013–16): Canada, 23%; China, 22%; France, 11%; Republic of Korea, 11%; and other, 33%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Unwrought indium, including powders	8112.92.3000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The 2017 estimated average free market price of indium was $205 per kilogram. The average monthly price began the year at $210 per kilogram in January and remained level for the first 3 months of the year, after which it decreased from April to July, falling to $193 per kilogram. The average monthly price then increased through October, rising to $215 per kilogram.

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INDIUM

In China, Fanya Metal Exchange warehouses reportedly held 3,600 tons of indium as of November 2017, and no information was available as to when the inventory would be released into the market. A China-based tin producer partnered with a United States-based producer of indium-based products to construct an ITO production plant in China. ITO is a semiconducting compound used in flat-panel displays for smartphones, monitors, and other electronic devices. In early 2017, China's Ministry of Commerce implemented an export license system and eliminated the previously used export quota system, which limited the amount of indium that could be exported. This new policy was expected to encourage exports of indium.

A Belgium-based zinc producer resumed production of indium at its zinc plant in Auby, France, in early 2017. The indium production plant at the zinc smelter had been shut down in November 2015 owing to a fire. The Auby plant previously produced 89 tons of indium between 2012 and 2014.

A Belgium-based materials technology company announced in late 2017 that they would be shutting down their ITO production operations in Providence, RI, by the end of 2017, and selling off its remaining ITO production to its joint-venture partner in China, a producer of minor-metals-based products.

World Refinery Production and Reserves:

	Refinery production[e]		Reserves[5]
	2016	**2017**	
United States	—	—	Quantitative estimates of reserves are not available.
Belgium	20	20	
Canada	71	70	
China	300	310	
France	—	20	
Japan	70	70	
Korea, Republic of	210	215	
Peru	10	10	
Russia	5	5	
World total (rounded)	680	720	

World Resources: 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—most deposits of these minerals are subeconomic for indium.

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; PEDOT [poly(3,4-ethylene dioxythiophene)] has also been developed as a substitute for ITO in flexible displays and organic light-emitting diodes; and 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 replace ITO in LCDs. Gallium arsenide can substitute for indium phosphide in solar cells and in many semiconductor applications. Hafnium can replace indium in nuclear reactor control rod alloys.

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

[1]Assumed to equal imports.

[2]Price is based on 99.99%-minimum-purity indium; delivered duty paid U.S. buyers; in minimum lots of 50 kilograms. Source: Platts Metals Week.

[3]Price is based on 99.99%-minimum-purity indium at warehouse (Rotterdam). Source: Metal Bulletin.

[4]Defined as imports – exports.

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

IODINE

(Data in metric tons elemental iodine unless otherwise noted)

Domestic Production and Use: Iodine was produced from brines in 2017 by three companies operating in Oklahoma. U.S. iodine production in 2017 was withheld to avoid disclosing company proprietary data. The average cost, insurance, and freight value of iodine imports in 2017 was estimated to be $20 per kilogram.

Because domestic and imported iodine were used by downstream manufacturers to produce many intermediate iodine compounds, it was difficult to establish an accurate end-use pattern. Organic iodine compounds, which included ethyl and methyl iodide, ethylenediamine dihydroiodide, and povidine iodine were estimated to account for more than 50% of domestic iodine consumption in 2017. Iodine and its compounds are primarily used in x-ray contrast media, pharmaceuticals, liquid-crystal-display (LCD) screens, and iodophors, in descending order.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production	W	W	W	W	W
Imports for consumption	5,960	5,360	5,630	4,320	4,300
Exports	1,130	1,240	1,210	1,050	1,100
Consumption:					
Apparent[1]	W	W	W	W	W
Reported	4,050	3,740	3,620	4,530	4,500
Price, average c.i.f. value, dollars per kilogram, crude	42.77	37.04	27.74	22.71	20.00
Employment, number[e]	60	60	60	60	60
Net import reliance[2] as a percentage of reported consumption	>50	>50	>50	>50	>50

Recycling: Small amounts of iodine were recycled.

Import Sources (2013–16): Chile, 88%; Japan, 11%; and other, <1%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Iodine, crude	2801.20.0000	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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IODINE

<u>Events, Trends, and Issues</u>: According to trade publications, spot prices of iodine crystal averaged about $20 per kilogram at the beginning of 2017 and increased to an average of about $23 per kilogram in September 2017. However, iodine prices were still considerably less than the historically high levels of $65 to $85 per kilogram in late 2012 and early 2013. Price increases were attributed to reduced iodine production in South America combined with steady demand. Demand for x-ray contrast media led market growth for iodine, especially in developing countries, where access to healthcare continues to increase.

As in recent years, Chile was the world's leading producer of iodine, followed by Japan and the United States. Excluding United States production, Chile accounted for about 65% of world production in 2017. Most of the world's iodine supply comes from three areas: the Chilean desert nitrate mines, the oil and gas fields in Japan, and northwestern Oklahoma.

<u>World Mine Production and Reserves</u>: Reserves for Chile were revised based on company and Government reports.

	Mine production		Reserves[3]
	2016	2017[e]	
United States	W	W	250,000
Azerbaijan	210	200	170,000
Chile	21,200	20,000	700,000
Indonesia	15	15	100,000
Japan	10,600	10,600	5,000,000
Russia	—	—	120,000
Turkmenistan	500	500	70,000
World total (rounded)	[4]32,500	[4]31,000	6,400,000

<u>World Resources</u>: In addition to the reserves shown above, seawater contains 0.06 parts 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.

<u>Substitutes</u>: 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. W Withheld to avoid disclosing company proprietary data. — Zero.

[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 of metal unless otherwise noted)

Domestic Production and Use: The iron and steel industry and ferrous foundries produced goods in 2017 with an estimated value of about $147 billion, up from $130 billion in 2016. Pig iron was produced by three companies operating integrated steel mills in nine locations. Fifty-four companies produced raw steel at 110 minimills. Combined production capacity was about 111 million tons. Indiana accounted for 27% of total raw steel production, followed by Ohio, 12%; Michigan, 6%; and Pennsylvania, 6%, with no other State having more than 5% of total domestic raw steel production. The distribution of steel shipments was estimated to be warehouses and steel service centers, 28%; construction, 20%; transportation (predominantly automotive), 17%; cans and containers, 2%; and other, 33%.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Pig iron production[2]	30.3	29.4	25.4	22.3	23
Raw steel production	86.9	88.2	78.8	78.5	82
Basic oxygen furnaces, percent	39.4	37.4	37.3	33.0	32
Electric arc furnaces, percent	60.6	62.6	62.7	67.0	68
Continuously cast steel, percent	98.8	98.5	99.0	99.4	99
Shipments:					
Steel mill products	86.6	89.1	78.5	78.5	83
Steel castings[e, 3]	0.4	0.4	0.4	0.4	0.4
Iron castings[e, 3]	4.0	4.0	4.0	4.0	4.0
Imports:					
Steel mill products	29.2	40.2	35.2	30.0	36
Semifinished products	6.6	9.6	6.6	6.1	8.4
Exports, steel mill products	11.5	10.9	9.0	8.4	11
Consumption, apparent (steel)[4]	98	107	99	95	100
Producer price index for steel mill products (1982=100)[5]	195.0	200.2	177.1	167.8	188
Stocks, service centers, yearend[6]	7.6	9.0	7.5	6.6	7
Total employment, average, number:					
Blast furnaces and steel mills[5]	90,900	91,000	87,000	83,600	83,000
Iron and steel foundries[5]	69,400	67,600	64,900	65,000	64,000
Net import reliance[7] as a percentage of apparent consumption	12	30	22	17	18

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

Import Sources (2013–16): Canada, 15%; Brazil, 13%; Republic of Korea, 12%; Mexico, 9%; and other, 51%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Carbon steel:		
Semifinished	7207.00.0000	Free.
Sheets, hot-rolled	7208.10.0000	Free.
Hot-rolled, pickled	7208.10.1500	Free.
Cold-rolled	7209.00.0000	Free.
Galvanized	7210.00.0000	Free.
Bars, hot-rolled	7213.00.0000	Free.
Structural shapes	7216.00.0000	Free.
Stainless steel:		
Semifinished	7218.00.0000	Free.
Cold-rolled sheets	7219.31.0000	Free.
Bars, cold-finished	7222.20.0000	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

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IRON AND STEEL

Events, Trends, and Issues: China's steel mills make about one-half of the world's raw steel, exporting nearly 100 million tons worldwide, and thus strongly influencing world steel markets. Recently, in response to a number of trade petitions lodged in North America and Europe, the steel sector in China stated its intent to reduce excess steel output to address the issue of overcapacity. The Government of China pledged to remove as much as 150 million tons per year of steel production capacity by 2020, beginning with induction furnaces, poorly integrated mills, previously idled facilities, subscale equipment, and unprofitable mills. Following these closures, capacity could be reduced to about 700 million tons.

The American Society of Civil Engineers 2017 report card rated the United States infrastructure as a "D+". The Society, along with the American Iron and Steel Institute, called for commitments to fund long-term, multiyear projects that would rebuild bridges, energy infrastructure, railroads, roads, and waterways, which would require large quantities of iron and steel. They called for steel used in these projects to be made in the United States.

Lighter, stronger steels have been developed for use in several vehicle models to compete against aluminum as automobile manufacturers redesign vehicles to increase fuel efficiency. By 2025, high-strength steel in vehicles built in North America is projected to increase by 76% above the 2015 average. Global demand for press-hardened steel sheet, which is strong and malleable for complex stamped parts, was projected to increase by 36% by 2020.

In April 2017, the Federal Government began an investigation to determine whether steel imports pose a threat to national security under the authority of Section 232 of the Trade Expansion Act of 1963. The U.S. steel industry asserts that practices by Governments of other steel-producing countries distort global markets, and excess steel is dumped into the United States, threatening national security. Others believe that this investigation will harm U.S. steel-consuming industries, which depend on a reliable, economical supply of steel imports.

World Production:

	Pig iron		Raw steel	
	2016	2017[e]	2016	2017[e]
United States	22	23	78	82
Brazil	25	28	31	34
China	704	730	808	843
France	10	11	14	16
Germany	28	28	42	44
India	62	65	96	99
Japan	81	78	105	104
Korea, Republic of	46	47	69	70
Russia	52	60	71	70
Taiwan	15	15	22	23
Turkey	10	11	33	37
Ukraine	24	20	24	21
United Kingdom	6	6	8	8
Other countries	70	79	209	224
World total (rounded)	1,160	1,200	1,610	1,700

World Resources: Not applicable. See Iron Ore and Iron and Steel Scrap 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 motor vehicle industry; aluminum, concrete, and wood in construction; and aluminum, glass, paper, and plastics in containers.

[e]Estimated.
[1]Production and shipments data source is the American Iron and Steel Institute; see also Iron and Steel Scrap and Iron Ore.
[2]More than 95% of iron made is transported in molten form to steelmaking furnaces located at the same site.
[3]Source: U.S. Census Bureau. North American Industry Classification System: 3311, 331511, 331512, and 331513.
[4]Defined as steel shipments + imports of steel mill products – exports + adjustments for industry stock changes – imports of semifinished steel products.
[5]Source: U.S. Department of Labor, Bureau of Labor Statistics.
[6]Steel mill products. Source: Metals Service Center Institute.
[7]Defined as imports – exports + adjustments for industry stock changes.

IRON AND STEEL SCRAP[1]

(Data in million metric tons of metal unless otherwise noted)

Domestic Production and Use: In 2017, the total value of domestic purchases (receipts of ferrous scrap by all domestic consumers from brokers, dealers, and other outside sources) and exports was estimated to be $15.9 billion, approximately 28% more than that of 2016. U.S. apparent steel consumption, an indicator of economic growth, increased to about 100 million tons in 2017. Manufacturers of pig iron, raw steel, and steel castings accounted for about 85% of 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 15% to produce cast iron and steel products, such as machinery parts, motor blocks, and pipe. 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.

During 2017, raw steel production was an estimated 82 million tons, up by 4% from 78.5 million tons in 2016; annual steel mill capacity utilization was about 75% compared with 71% for 2016. Net shipments of steel mill products were an estimated 83 million tons, about 6% higher than those in 2016.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Home scrap	8.5	7.1	6.3	7.8	7
Purchased scrap[2]	77	62	67	53	66
Imports for consumption[3]	3.9	4.2	3.5	3.9	3
Exports[3]	18	15	13	13	14
Consumption, reported	59	59	53	53	44
Consumption, apparent[4]	71	58	64	52	62
Price, average, dollars per metric ton delivered, No. 1 Heavy Melting composite price, Iron Age Average, Pittsburgh, Philadelphia, Chicago	365	351	213	196	265
Stocks, consumer, yearend	4.2	4.3	4.4	4.7	4.0
Employment, dealers, brokers, processors, number[5]	30,000	30,000	30,000	30,000	30,000
Net import reliance[6] 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.

In the United States, the primary source of old steel scrap was automobiles. The recycling rate for automobiles in 2014, the latest year for which statistics were available, was about 106%. A recycling rate greater than 100% is a result of the steel industry recycling more steel from automobiles than was used in the domestic production of new vehicles. The automotive recycling industry recycled about 14 million tons of steel from end-of-life vehicles using more than 350 car shredders, the equivalent of nearly 12 million automobiles. More than 7,000 vehicle dismantlers throughout North America resell parts.

The recycling rates for appliances and steel cans in 2014 were 90% and 67%, respectively; this was the latest year for which statistics were available. Recycling rates for construction materials in 2014 were about 98% for plates and beams and 70% for rebar and other materials. The recycling rates for appliance, can, and construction steel are expected to increase in the United States and in emerging industrial countries at an even greater rate. Public interest in recycling continues, and recycling is becoming more profitable and convenient as environmental regulations for primary production increase.

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IRON AND STEEL SCRAP

Recycling of scrap plays an important role in the conservation of energy because the remelting of scrap requires much less energy than the production of iron or steel products from iron ore. 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 consists of approximately 58% post-consumer (old, obsolete) scrap, 24% prompt scrap (produced in steel-product manufacturing plants), and 18% home scrap (recirculating scrap from current operations).

Import Sources (2013–16): Canada, 79%; Mexico, 7%; United Kingdom, 5%; Sweden, 5%; and other, 4%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Iron and steel waste and scrap:		
No. 1 Bundles	7204.41.0020	Free.
No. 1 Heavy Melting	7204.49.0020	Free.
No. 2 Heavy Melting	7204.49.0040	Free.
Shredded	7204.49.0070	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Events, Trends, and Issues: Steel mill production capacity utilization peaked at 80.9% in April 2012 and reached 75.2% in February 2017. Scrap prices fluctuated during the first 7 months of 2017, between about $218 and $291 per ton. Composite prices published by Scrap Price Bulletin for No. 1 Heavy Melting steel scrap delivered to purchasers in Chicago, IL, Philadelphia, PA, and Pittsburgh, PA, averaged about $261 per ton during the first 7 months of 2017. Exports of ferrous scrap increased in 2017 to an estimated 14 million tons from nearly13 million tons during 2016, primarily to Turkey, Mexico, and Taiwan, in descending order of export tonnage. The value of exported scrap increased from $3.6 billion in 2016 to an estimated $4.4 billion in 2017. World steel demand was expected to increase slightly from 1.54 billion tons in 2017 to 1.58 billion tons in 2018.

In early September 2017, Hurricane Harvey brought unprecedented rainfall and flooding to southeast Texas and southwest Louisiana, destroying or damaging an estimated 500,000 to one million vehicles. Damage of large appliances—washers, dryers, refrigerators, and air conditioners—was also expected to be very high. If 500,000 vehicles are shredded, that would be double the number shredded after Superstorm Sandy in the eastern United States in 2012. Both Harvey and then Hurricane Irma, which hit Florida about 10 days later, were expected to cause scrap prices to increase significantly. However, by October, scrap appeared to be so plentiful that domestic and export prices began to decline.

World Mine Production and Reserves: Not applicable.

World Resources: Not applicable.

Substitutes: About 2.0 million tons of direct-reduced iron was used in the United States in 2017 as a substitute for iron and steel scrap, down from 4.8 million tons in 2016.

[e]Estimated. E Net exporter.
[1]See also Iron and Steel and Iron Ore.
[2]Receipts – shipments by consumers + exports – imports.
[3]Excludes used rails for rerolling and other uses, and ships, boats, and other vessels for scrapping.
[4]Defined as secondary (old) scrap + imports – exports + adjustments for industry stock changes.
[5]Estimated, based on 2002 Census of Wholesale Trade for 2010 through 2014.
[6]Defined as imports – exports + adjustments for industry stock changes.

IRON AND STEEL SLAG

(Data in million metric tons unless otherwise noted)

Domestic Production and Use: In the making of crude (or pig) iron and crude steel, slagging agents are added to strip impurities from the iron ore in the blast furnaces and from the crude iron and scrap steel feeds to the steel furnaces. The impurities and slagging agents combine to form iron and steel (ferrous) slags, which are tapped separately from the metals and which, after cooling and processing, primarily find a ready market in the construction industry. Data are unavailable on actual U.S. ferrous slag production, but it is estimated to have been in the range of 15 to 20 million tons in 2017. Domestic slag sales[1] in 2017 amounted to an estimated 15 million tons, valued at about $350 million (ex-plant). Blast furnace slag accounted for about 50% of the tonnage sold and had a value of about $300 million; about 85% of this value was from sales of granulated slag. Steel slag produced from basic oxygen and electric arc furnaces accounted for almost all of the remainder.[2] Slag was processed by about 25 companies servicing active iron and steel facilities or reprocessing old slag piles at about 175 processing plants (including some iron and steel plants with more than one slag-processing facility) in 30 States; included in this tally are some facilities that grind and sell ground granulated blast furnace slag (GGBFS) based on imported unground feed.

Prices listed in the table below are weighted averages (rounded) for iron and steel slags sold for a variety of applications. Actual prices per ton ranged widely in 2017, from a few cents for some steel slags at a few locations to about $104 for some GGBFS. Air-cooled iron slag and steel slag are used primarily as aggregates in concrete (air-cooled iron slag only), asphaltic paving, fill, and road bases; both slag types also can be used as a feed for cement kilns. Almost all GGBFS is used as a partial substitute for portland cement in concrete mixes or in blended cements. Pelletized slag is generally used for lightweight aggregate but can be ground into material similar to GGBFS. Owing to low unit values, most slag types can be shipped only short distances by truck, but rail and waterborne transportation allow for greater distances. Because of much higher unit values, GGBFS can be shipped longer distances, including from overseas.

Salient Statistics—United States:	2013	2014	2015	2016[e]	2017[e]
Production (sales)[1, 3]	15.5	16.6	17.7	16.0	15.0
Imports for consumption[4]	1.7	1.8	1.5	2.0	2.2
Exports	([5])	0.1	([5])	([5])	([5])
Consumption, apparent[6]	15.5	16.5	17.7	16.0	15.0
Price, average value, dollars per ton, f.o.b. plant[7]	17.50	19.00	19.50	22.00	23.00
Employment, number[e]	1,700	1,700	1,700	1,600	1,500
Net import reliance[8] as a percentage of apparent consumption	11	10	8	12	15

Recycling: Following removal of 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 the slag processors, but data on metal returns are unavailable.

Import Sources (2013–16): Canada, 27%; Japan, 26%; Spain, 19%; Germany (including the Netherlands and Switzerland in 2015), 7%; and other, 21%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Granulated slag	2618.00.0000	Free.
Slag, dross, scale, from manufacture of iron and steel	2619.00.0000	Free.

Depletion Allowance: Not applicable.

Government Stockpile: None.

Events, Trends, and Issues: The supply of blast furnace slag continues to be problematic in the United States because of the closure and (or) continued idling of a number of U.S. blast furnaces in recent years (including four in 2015), the lack of construction of new furnaces, and the depletion of old slag piles. Locally produced granulated blast furnace slag was available only in limited supplies because, at yearend 2017, granulation cooling was available at only two active U.S. blast furnaces (down from three in 2014). Installation of granulation cooling was continuing to be evaluated at a few blast furnaces, but it remained unclear if this would be cost-effective given the economic uncertainties in operating blast furnaces. Pelletized blast furnace slag was in very limited supply (one site only), and it was uncertain if any additional pelletizing capacity was planned.

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IRON AND STEEL SLAG

Basic oxygen furnace steel slag from domestic furnaces also has become less available recently because of the closure or idling of several integrated iron and steel complexes, although the existence at many sites of large slag stockpiles can allow for slag processing to continue even several years after the cessation of furnace operations. Nonetheless, the long-term supply of steel slag will increasingly rely on electric arc furnaces, which now contribute the majority of U.S. steel production. Domestic- and import-supply constraints appear to have limited domestic consumption of GGBFS in recent years. Although prices have increased, sales volumes for GGBFS have failed to match the relative increases that have characterized the overall U.S. cement market since 2010. Long-term demand for GGBFS likely will increase because its use in concrete yields a superior product in many applications and reduces the unit carbon dioxide (CO_2) emissions footprint of the concrete related to the portland cement (clinker) content.

Recent regulations to restrict emissions of CO_2 and mercury by coal-fired powerplants, together with powerplant closures or conversion of others to natural gas, have led to a reduction in the supply of fly ash in some areas, including that of material for use as cementitious additive for concrete, with the result that fly ash imports have increased. Fly ash shortages have the potential to increase future demand for GGBFS, but the availability of granulated slag will increasingly depend on imports, either of ground or unground material. Imported slag availability may be constrained by increasing international demand for the same material and because not all granulated slag produced overseas is of high quality. Restrictions on mercury emissions by cement plants enacted in 2015 may reduce demand for fly ash as a raw material for clinker manufacture, and this could lead to use of air-cooled and steel slags as replacement raw materials.

World Mine Production and Reserves: Slag is not a mined material and thus the concept of reserves does not apply to this mineral commodity. Slag production data for the world are unavailable, but may be estimated as equivalent to 25% to 30% of crude (pig) iron production and steel furnace slag as about 10% to 15% of crude steel output. On this basis, it is estimated that global iron slag output in 2017 was on the order of 300 million to 360 million tons, and steel slag about 170 million to 250 million tons.

World Resources: Not applicable.

Substitutes: In the construction sector, ferrous slags compete with crushed stone and sand and gravel as aggregates, 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, and to a lesser degree with silica fume. In this respect, GGBFS also competes with portland cement itself. 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 are generally in much more restricted supply than ferrous slags.

[e]Estimated.
[1]Processed slag sold rather than that processed or produced during the year. Excludes any entrained metal that may be recovered during slag processing and then sold separately or returned to iron and, especially, steel furnaces. Data are incomplete regarding slag returns to the furnaces.
[2]There were very minor sales of open hearth furnace steel slag from stockpiles but no domestic production of this slag type in 2013–17.
[3]Data include sales of imported granulated blast furnace slag, either after domestic grinding or still unground, and exclude sales of pelletized slag (proprietary but very small).
[4]Official (U.S. Census Bureau) data adjusted by the U.S. Geological Survey. In some years, the official data, which are supposed to be granulated blast furnace slag only, appear to have understated the true imports of this material by as much as 0.4–0.5 million tons annually for the period shown, and have included significant tonnages of 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.
[5]Less than 0.05 million tons.
[6]Defined as total sales of slag (including those from imported feed) − exports, but does not significantly differ from total sales owing to the very small export tonnages.
[7]Rounded to the nearest $0.50 per ton.
[8]Defined as imports – exports.

IRON ORE[1]

(Data in million metric tons, usable ore, unless otherwise noted)

Domestic Production and Use: In 2017, mines in Michigan and Minnesota shipped 97% of the usable iron ore products in the United States—the remaining 3% of domestic iron ore was produced for nonsteel end uses—with an estimated value of $3.2 billion. Seven open-pit iron ore mines, each including a concentration and pelletizing plant, and two iron metallic plants, including one direct-reduced iron (DRI) plant and one hot-briquetted iron (HBI) plant, operated during the year to supply steelmaking raw materials. The United States was estimated to have produced 1.8% and consumed 1.4% of the world's iron ore output.

Salient Statistics—United States:[2]	2013	2014	2015	2016	2017[e]
Production:					
Iron ore	52.8	56.1	46.1	41.8	46.3
Iron metallics	0.5	2.0	1.4	1.5	2.1
Shipments	53.4	55.0	43.5	43.6	44.7
Imports for consumption	3.2	5.1	4.6	3.0	3.5
Exports	11.0	12.1	7.5	8.8	12.0
Consumption:					
Reported (ore and total agglomerate)	44.2	44.4	38.5	34.5	29.0
Apparent[3]	47.1	47.0	39.7	39.4	36.1
Value, U.S. dollars per metric ton	87.42	84.43	81.19	73.11	75.00
Stocks, mine, dock, and consuming plant, yearend, excluding byproduct ore	2.35	4.46	7.86	6.10	7.70
Employment, mine, concentrating and pelletizing plant, number	5,644	6,273	4,802	4,710	4,500
Net import reliance[4] as a percentage of apparent consumption (iron content of ore)	E	E	E	E	E

Recycling: None. See Iron and Steel Scrap.

Import Sources (2013–16): Canada, 47%; Brazil, 39%; and other, 14%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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: U.S. iron ore production was estimated to have increased in 2017 owing to one mine that restarted in early 2017 and two mines that operated for the full year following periods of being idled in 2016. Despite an overall increase in raw steel production from 79 million tons in 2016 to an estimated 82 million tons in 2017, the share of steel produced by basic oxygen furnace, the process that uses iron ore, decreased to 39% from 45% in 2013. Continued volatility in global spot iron ore prices in 2017 and continued lower iron ore prices suppressed development of new iron ore projects and exploration activities. In October 2017, the spot price for iron ore fines (62% iron content) imported into China (cost and freight into Tianjin port) was $61.66 per ton, an increase from $59.09 in October 2016, but down from the 2017 high of $89.44 in February and the recent high of $132.57 in October 2013.

During 2017, bankruptcy proceedings continued for a company's project to develop a 7-million-metric-ton-per-year iron ore mine and processing plant in Minnesota and another company that owned a pellet plant in Indiana and three tailings reclamation operations in Minnesota. A third company purchased the holdings of both bankrupt companies.

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IRON ORE

The new owner planned to restart two of the reclamation operations in Minnesota and complete the integrated iron facility. One of the tailings operations was expected to reopen in 2018. The integrated operation was expected to be complete in late 2019 or early 2020 with subsequent plans to develop a DRI or HBI facility on-site.

Globally, iron ore production in 2017 increased by 20 million tons from that of 2016, following an increase of 30 million tons in 2016 from that of 2015. Over the 5-year period from 2012 through 2016, global iron ore production increased by 280 million tons. Production of iron ore from Australia and India, the leading and fourth-ranked iron ore producers in the world, respectively, collectively increased by 90 million tons from 2015 to 2016 and by about 30 million tons from 2016 to 2017, whereas production from China, the third-ranked producer, decreased by 27 million tons and 13 million tons. The global iron and steel market continued to attempt to rebalance following an ongoing glut in production for raw steel and steel products from China and iron ore from Australia and Brazil. Global steel consumption was forecast to increase from 1.52 billion tons in 2016 to 1.54 billion tons and 1.55 billion tons in 2017 and 2018, respectively.

Despite the global increase in production, 27 of the top 50 iron-ore-producing countries decreased production. Global steel production increased only slightly in 2017 as iron ore production from the world's leading mining companies increased, but small-scale and high-cost iron ore producers continued to idle operations. Countries in West Africa which were affected by the Ebola virus, specifically Sierra Leone, continued to face difficulties in producing iron ore owing to declines in price and labor shortages.

World Mine Production and Reserves: Reserves for Australia were revised based on Government information. In the United States, reserves were adjusted to reflect the permanent closure of a mine in 2016.

	Mine production					
	Usable ore		Iron content		Reserves[5]	
	2016	2017[e]	2016	2017[e]	Crude ore	Iron content
United States	42	46	26	28	2,900	760
Australia	858	880	531	545	[6]50,000	[6]24,000
Brazil	430	440	275	280	23,000	12,000
Canada	47	47	29	29	6,000	2,300
China	348	340	216	210	21,000	7,200
India	185	190	114	120	8,100	5,200
Iran	35	35	23	23	2,700	1,500
Kazakhstan	34	34	10	10	2,500	900
Russia	101	100	60	60	25,000	14,000
South Africa	66	68	42	42	1,200	770
Sweden	27	27	16	16	3,500	2,200
Ukraine	63	63	39	39	[7]6,500	[7]2,300
Other countries	116	110	72	68	18,000	9,500
World total (rounded)	2,350	2,400	1,450	1,500	170,000	83,000

World Resources: U.S. resources are estimated to be 110 billion tons of 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 crude 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, which allow hematite to be recovered from tailings basins and pelletized.

[e]Estimated. E Net exporter.
[1]Data are for iron ore used as a raw material in steelmaking unless otherwise noted. See also Iron and Steel and Iron and Steel Scrap.
[2]Salient statistics are for all forms of iron ore used in steelmaking, except iron metallics, which include DRI, hot-briquetted iron, and iron nuggets. Iron metallics production is listed separately and based on consumption of imported iron ore.
[3]Defined as production + imports – exports + adjustments for industry stock changes.
[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 reserves were about 24 billion tons for crude ore and 10 billion tons for iron content.
[7]For Ukraine, reserves consist of the A+B categories of the former Soviet Union's reserves classification system.

IRON OXIDE PIGMENTS

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Iron oxide pigments (IOPs) were mined domestically by three companies in three States. Production, which was withheld to avoid disclosing company proprietary data, decreased in 2017 from that of 2016. Six companies, including the three producers of natural IOPs, processed and sold about 55,000 tons of finished natural and synthetic IOPs with an estimated value of $85 million, significantly below the most recent sales peak of 88,100 tons in 2007. About 54% of natural and synthetic finished IOPs were used in concrete and other construction materials; 20% in coatings and paints; 9% in foundry sands and other foundry uses; 4% in industrial chemicals; 3% in animal food; 2% in glass and ceramics; 1% in fertilizer; 1% in plastics, rubber, and cosmetics combined; and 6% in other uses.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Mine production, crude	W	W	W	W	W
Sold or used, finished natural and synthetic IOP	47,200	45,300	53,500	52,500	55,000
Imports for consumption	165,000	175,000	176,000	179,000	190,000
Exports, pigment grade	8,170	8,790	8,930	15,800	13,000
Consumption, apparent[1]	204,000	212,000	221,000	216,000	232,000
Price, average value, dollars per kilogram[2]	1.60	1.58	1.46	1.57	1.54
Employment, mine and mill	50	50	55	60	60
Net import reliance[3] as a percentage of reported consumption	>50	>50	>50	>50	>50

Recycling: None.

Import Sources (2013–16): Natural: Cyprus, 49%; Spain 27%; France, 12%; Austria, 11%; and other, 1%. Synthetic: China, 52%; Germany, 27%; and Brazil, Canada, and other, 7% each.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Natural:		
Micaceous iron oxides	2530.90.2000	2.9% ad val.
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 val.
Red	2821.10.0020	3.7% ad val.
Yellow	2821.10.0030	3.7% ad val.
Other	2821.10.0040	3.7% ad val.
Earth colors	2821.20.0000	5.5% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: In 2017, domestic mine production of crude natural IOPs decreased somewhat owing to a major producer reducing mining output this year to use stockpiled feedstock from excess crude production in 2016. Production and sales of finished natural and synthetic IOPs increased by about 5%. Domestic production of crude natural IOPs and production and sales of synthetic IOPs are expected to increase in 2018. This is partly owing to an increase in construction and refurbishment projects resulting from significant damage to structures and infrastructure that took place in 2017 as the result of extensive hurricanes along the Gulf Coast and the southeastern United States and extensive wildfires in some Western States.

Residential construction, in which IOPs are commonly used to color concrete block and brick, ready-mixed concrete, and roofing tiles, increased in the first 9 months of 2017 compared with the same period in 2016; housing starts and completions rose by about 3% and 11%, respectively. Spending on residential construction increased by 11% during the first 9 months of 2017 compared with the same period in 2016. Spending on nonresidential construction, which accounted for 57% of construction expenditures, increased slightly in the first 9 months of 2017 compared with those of 2016.

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IRON OXIDE PIGMENTS

Exports of pigment-grade IOPs decreased by about 20% during the first 9 months of 2017 compared with the same period in 2016, mostly owing to a significant decrease in exports to Belgium; more than 87% of pigment-grade IOPs went to Mexico, China, Belgium, Germany, Taiwan, and Chile, in descending order of quantity. Exports of other grades of iron oxides and hydroxides, more than three times those of pigment grade, decreased by about 10% during the first 9 months of 2017 compared with the same period in 2016. About 98% of exports of other grades of iron oxides and hydroxides went to Spain, China, Canada, Mexico, South Africa, Australia, and Israel, in descending order of quantity. Total imports of natural and synthetic IOPs increased by 6% in 2017 compared with those in 2016.

A company in Utah continued to ramp up production and marketing of its high-purity “advanced natural” iron oxides, mostly composed of goethite and hematite, and it established contracts with two specialty chemical materials distributors to sell its natural IOP products in most of the Midwestern and Western States, especially to the paints and coatings industries. The company also marketed IOP products to the energy and biogas industries as desulfurization catalysts to compete with costly synthetic iron oxide catalysts commonly used in scavenging the highly corrosive hydrogen sulfide gas produced in the anaerobic conversion of biomass.

A major international IOP-producing company, with production facilities in many countries, acquired a U.S. company that historically was a significant producer of crude and synthetic IOPs. The U.S. company, which ceased crude and synthetic IOP production several years ago, continued to produce a variety of IOPs and ecofriendly, transparent IOP products by the processing of waste materials from current and closed coal and iron ore mines, especially in the Eastern States.

A major iron-oxide-producing company based in Germany was planning to expand its synthetic iron oxide pigment production capacities of red and black pigments in Germany and yellow pigments in Brazil, reaching a total global production capacity of 400,000 tons per year by 2019.

World Mine Production and Reserves:

	Mine production		Reserves[4]
	2016	2017[e]	
United States	W	W	Moderate
Austria (micaceous IOP)	3,500	3,500	NA
Cyprus (umber)	3,500	3,500	Moderate
France	1,000	1,000	NA
Germany[5]	200,000	200,000	Moderate
India (ocher)	2,200,000	2,000,000	55,000,000
Pakistan (ocher)	40,000	40,000	Moderate
Spain (ocher and red iron oxide)	16,000	16,000	Large
World total	[6]NA	[6]NA	Large

World Resources: 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 probably 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 IOPs + imports – exports.
[2]Average unit value for finished iron oxide pigments sold or used by U.S. producers.
[3]Defined as imports – exports.
[4]See Appendix C for resource and reserve definitions and information concerning data sources.
[5]Includes natural and synthetic iron oxide pigment.
[6]A significant number of other countries, including Azerbaijan, Brazil, China, Honduras, Iran, Italy, Kazakhstan, Lithuania, Paraguay, Russia, South Africa, Turkey, Ukraine, and the United Kingdom, are thought to produce IOPs, but output is not reported and no basis is available to make reliable estimates of production.

KYANITE AND RELATED MINERALS

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In Virginia, one firm with integrated mining and processing operations produced kyanite from two hard-rock open pit mines and a 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 are 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 uneconomic 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 65% of the refractory usage was consumed by the iron and steel industries, and the remainder was used by industries that manufacture 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.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Mine	[1]110	[1]89	[1]109	[1]79.7	90
Synthetic mullite	W	W	W	W	W
Imports for consumption (andalusite)	4	4	12	3	8
Exports (kyanite)	42	40	40	37	40
Consumption, apparent	W	W	W	W	W
Price, average, dollars per metric ton:[2]					
U.S. kyanite, raw concentrate	300	260	270	270	270
U.S. kyanite, calcined	450	370	410	410	420
Andalusite, Transvaal, South Africa	320	340	330	330	340
Employment, kyanite mine, office, and plant, number[e]	140	150	155	150	150
Employment, mullite plant, office, and plant, number[e]	210	230	220	210	210
Net import reliance[3] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Insignificant.

Import Sources (2013–16): South Africa, 74%; Peru, 19%; France, 5%; United Kingdom 1%, and other, 1%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–17**
Andalusite, kyanite, and sillimanite	2508.50.0000	Free.
Mullite	2508.60.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

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KYANITE AND RELATED MINERALS

Events, Trends, and Issues: Crude steel production in the United States, which ranked fourth in the world, increased by about 2.4% in the first 8 months of 2017 compared with that of the same period in 2016, indicating a similar change in consumption of kyanite-mullite refractories. Total world steel production increased by nearly 5% during the first 8 months of 2017 compared with the same period in 2016. The increase in world steel production during the first 8 months of 2017 was the result of incremental to small increases in production, both in developed and developing countries, especially in Asia. Despite a continuing deceleration in growth, China still led with the largest increase in steel production; increases also took place in the Philippines and Vietnam. Of the total world refractories market, which was estimated to be approximately 40 million tons, crude steel manufacturing consumed more than 70% of refractories production.

The availability of inexpensive refractory-grade bauxite from China, which accounted for about three-quarters of the refractories market share worldwide, continued to decrease. Andalusite and mullite could receive increasing consideration as alternative aluminosilicate refractory minerals to refractory bauxite, but the availability of andalusite may have been hampered by heavy rains and flooding that took place during the first quarter of 2017 in major andalucite-producing areas in South Africa and Peru. China was expected to have an economic growth rate approaching 7% in 2017 and continue to be the largest market for refractories. Slowing, but still above-average, growth is expected in most other portions of Asia. The economies of North America and Europe are expected to increase in 2018 with continued recovery in manufacturing and steel production, but may lag behind the worldwide average in the longer term with steel production increasing in India and shifting to less developed countries, such as Indonesia, the Philippines, and Vietnam. Demand for refractories in iron and steel production is expected to have larger increases in countries with higher rates of growth in steel production. Increased demand also is anticipated for refractories used to produce other metals and in the industrial mineral market because of increasing production of cement, ceramics, glass, and other mineral products.

Although slowed somewhat by adverse weather conditions, andalusite projects in Peru continued to progress. One facility increased production capacity by 10% and, at another andalusite project, the company continued exploration and construction of the processing facility as it sought a joint-venture investment partner, deemed necessary to proceed with production.

World Mine Production and Reserves:

	Mine production		Reserves[4]
	2016	2017[e]	
United States (kyanite)	80	90	Large
India (kyanite and sillimanite)	73	75	1,600
Peru (andalusite)	40	40	NA
South Africa (andalusite)	180	180	NA
World total (rounded)	[5]NA	[5]NA	NA

World Resources: 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 economic to mine at present. The characteristics of kyanite resources in the rest of the world are thought 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.
[1]Source: Virginia Department of Mines, Minerals and Energy.
[2]Source: Average of prices reported in Industrial Minerals.
[3]Defined as imports – exports.
[4]See Appendix C for resource and reserve definitions and information concerning data sources.
[5]In addition to the countries listed, France continued production of andalusite and Brazil, Camaroon, and China produced kyanite and related minerals. Output is not reported quantitatively, and no reliable basis is available for estimation of output levels.

LEAD

(Data in thousand metric tons of lead content unless otherwise noted)

Domestic Production and Use: Five lead mines in Missouri, plus five mines in Alaska, Idaho, and Washington that produced lead as a joint product, accounted for all domestic lead mine production. The value of the lead in concentrates mined in 2017, based on the average North American Market price for refined lead, was $778 million. It was estimated that the lead-acid battery industry accounted for more than 85% of reported U.S. lead consumption during 2017. 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:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Mine, lead in concentrates	339	378	370	346	313
Primary refinery	114	—	—	—	—
Secondary refinery, old scrap	1,150	1,020	1,050	1,000	1,010
Imports for consumption:					
Lead in concentrates	([1])	—	—	([1])	—
Refined metal, unwrought	485	593	521	533	700
Exports:					
Lead in concentrates	210	357	350	341	280
Refined metal, unwrought (gross weight)	42	55	56	43	30
Consumption:					
Reported	1,390	1,510	1,630	1,470	1,600
Apparent[2]	1,710	1,560	1,520	1,490	1,680
Price, average, cents per pound:					
North American market	110.0	106.2	91.2	94.4	112.9
London Metal Exchange, cash	97.2	95.0	81.0	84.8	102.4
Stocks, metal, producers, consumers, yearend	70	66	64	101	100
Employment, number:					
Mine and mill (average)[3]	1,690	1,760	1,840	1,800	1,550
Primary smelter, refineries	290	—	—	—	—
Secondary smelters, refineries	2,000	1,800	1,800	1,850	1,850
Net import reliance[4] as a percentage of apparent consumption, refined lead	26	34	31	33	40

Recycling: In 2017, about 1 million tons of secondary lead was produced, an amount equivalent to 60% of apparent domestic consumption. Nearly all secondary lead was recovered from old scrap, mostly lead-acid batteries.

Import Sources (2013–16): Metal, wrought and unwrought: Canada, 50%; Republic of Korea, 19%; Mexico, 14%; India, 4%; and other, 13%.

Tariff: Item	**Number**	**Normal Trade Relations[5] 12–31–17**
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.

Events, Trends, and Issues: During the first 10 months of 2017, the average London Metal Exchange (LME) cash price for lead was $1.04 per pound, 27% more than that in the same period of 2016. In the second half of 2017, prices reached a 6-year high, owing to a tight supply of concentrate and increased demand for refined lead. Global stocks of lead in LME-approved warehouses were 143,875 tons in mid-December, 26% less than those at yearend 2016.

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LEAD

In 2017, domestic mine production was estimated to have decreased from that in the previous year in all four States. Production at one mine in Idaho decreased by 90% owing to an employee strike, which began in March. The United States has become more reliant on imported refined lead in recent years owing to the closure of the last primary lead smelter in 2013.

Permitting and construction of a new secondary lead refinery in Nevada was completed. The plant was expected to have the capacity to produce about 80 tons per day of high-purity refined lead using electrochemical battery recycling technology, and was in the process of ramping up to full capacity. Exports of SLI batteries have been decreasing since 2014. During the first 10 months of 2017, 15.9 million spent SLI lead-acid batteries were exported, 9% less than those in 2016 and 32% less than 2015, indicating that U.S. producers may be using more domestic scrap.

According to the International Lead and Zinc Study Group,[6] global refined lead production in 2017 increased by 4% to 11.58 million tons, and metal consumption increased by 5% to 11.70 million tons, resulting in a production-to-consumption deficit of about 120,000 tons of refined lead.

World Mine Production and Reserves: Reserves estimate for Peru was revised based on a Government report.

	Mine production		Reserves[7]
	2016	2017[e]	
United States	346	313	5,000
Australia	453	450	[8]35,000
Bolivia	75	70	1,600
China	2,340	2,400	17,000
India	147	150	2,200
Mexico	232	230	5,600
Peru	314	300	6,000
Russia	250	250	6,400
Sweden	79	80	1,100
Turkey	76	70	860
Other countries	400	390	7,000
World total (rounded)	4,710	4,700	88,000

World Resources: 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. — Zero.
[1]Less than ½ unit.
[2]Defined as primary refined production + secondary refined production (old scrap) + refined imports – refined exports.
[3]Includes lead and zinc-lead mines for which lead was either a principal product or significant byproduct.
[4]Defined as imports – exports.
[5]No tariff for certain countries owing to special trade agreements. See the Harmonized Tariff Schedule of the United States.
[6]International Lead and Zinc Study Group, 2017, ILZSG session/forecasts: Lisbon, Portugal, International Lead and Zinc Study Group news release, October 30, 5 p.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]For Australia, Joint Ore Reserves Committee-compliant reserves were about 12 million tons.

LIME[1]

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2017, an estimated 18 million tons (20 million short tons) of quicklime and hydrate was produced (excluding independent commercial hydrators[2]), valued at about $2.3 billion. At yearend, 28 companies were producing lime, which included 18 companies with commercial sales and 10 companies that produced lime strictly for internal use (for example, sugar companies). These companies had 74 primary lime plants (plants operating quicklime kilns) in 28 States and Puerto Rico. Three of these 28 companies operated only hydrating plants in five States. In 2017, the five leading U.S. lime companies produced quicklime or hydrate in 21 States and accounted for 76% of U.S. lime production. Principal producing States were, in descending order of production, Missouri, Alabama, Ohio, Texas, and Kentucky. Major markets for lime were, in descending order of consumption, steelmaking, flue gas treatment, construction, chemical and industrial applications [such as the manufacture of fertilizer, glass, paper and pulp, precipitated calcium carbonate (PCC), and in sugar refining], water treatment, and nonferrous mining.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production[3]	19,200	19,500	18,300	17,700	18,000
Imports for consumption	394	414	391	376	360
Exports	271	320	346	329	320
Consumption, apparent[4]	19,300	19,600	18,300	17,700	18,000
Quicklime average value, dollars per ton at plant	117.80	119.10	121.50	121.00	123.00
Hydrate average value, dollars per ton at plant	140.60	142.20	146.40	145.50	149.00
Employment, mine and plant, number	5,100	5,100	NA	NA	NA
Net import reliance[5] as a percentage of apparent consumption	1	1	<1	<1	<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 in order to avoid duplication.

Import Sources (2013–16): Canada, 95%; Mexico, 5%; and other, negligible.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Calcined dolomite	2518.20.0000	3% ad val.
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 2017, domestic lime production was estimated to increase slightly from that of 2016, owing primarily to an increase in hydrated lime output. This also led to the slight increase in estimated value of production year over year.

In 2016, there were three companies that shut down quicklime production at 3 plants, bringing the total number of operating quicklime plants to 74 in 2017 from 77. One company shut down quicklime and PCC processes at its plant in Tacoma, WA, choosing instead to focus on hydrated lime production. One sugar cooperative closed its sugar beet processing facility in Torrington, WY, thereby eliminating one quicklime kiln from its manufacturing portfolio. One company shut down quicklime production at its Branchton facility in Slippery Rock, PA; since then, only hydrated lime has been produced at this location. In June 2017, another company acquired the Branchton plant's hydrated lime operations. 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. In 2017, the leading uses of hydrated lime were flue gas desulfurization at utility powerplants (13%); production of building construction materials, such as some mortars, plasters, and stuccos (10%); and treatment of wastewater (6%) and drinking water (5%).

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LIME

World Lime Production and Limestone Reserves:

	Production[e 6]		Reserves[7]
	2016	2017	
United States	17,700	18,000	Adequate for all countries listed.
Australia	2,000	2,000	
Belgium	1,500	1,500	
Brazil	8,100	8,300	
Bulgaria	1,400	1,500	
Canada (shipments)	1,900	1,900	
China	230,000	230,000	
Czechia	1,100	1,000	
France	2,500	2,600	
Germany	6,800	6,900	
India	16,000	16,000	
Iran	2,900	3,100	
Italy[8]	3,600	3,600	
Japan (quicklime only)	7,300	7,400	
Korea, Republic of	5,100	5,200	
Malaysia (sales)	1,600	1,600	
Poland	1,900	2,000	
Romania	2,000	2,000	
Russia (industrial and construction)	11,000	11,000	
South Africa (sales)	1,100	1,100	
Spain (sales)	1,800	1,800	
Turkey (sales)	4,300	4,500	
Ukraine	2,800	2,700	
United Kingdom	1,500	1,500	
Other countries	14,000	15,000	
World total (rounded)[9]	350,000	350,000	

World Resources: 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. NA Not available.
[1]Data are for quicklime, hydrated lime, and refractory dead-burned dolomite. Includes Puerto Rico.
[2]Excludes independent commercial hydrators that purchase quicklime for hydration to avoid double counting quicklime production.
[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 of lime or more are listed separately.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]Includes hydraulic lime.
[9]World production data are rounded to no more than two significant digits when estimated. Data reported by countries such as Canada, Japan, and the United States are rounded to three significant digits. Data may not add to totals shown.

LITHIUM

(Data in metric tons of lithium content unless otherwise noted)

Domestic Production and Use: The only lithium production in the United States was from a brine operation in Nevada. 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 was withheld to avoid disclosing company proprietary data.

Although lithium markets vary by location, global end-use markets are estimated as follows: batteries, 46%; ceramics and glass, 27%; lubricating greases, 7%; polymer production, 5%; continuous casting mold flux powders, 4%; air treatment, 2%; and other uses, 9%. Lithium consumption for batteries has increased significantly in recent years because rechargeable lithium batteries are used extensively in the growing market for portable electronic devices and increasingly are used in electric tools, electric vehicles, and grid storage applications. Lithium minerals were used directly as ore concentrates in ceramics and glass applications.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production	[1]870	W	W	W	W
Imports for consumption	2,210	2,130	2,750	3,140	3,430
Exports	1,230	1,420	1,790	1,520	1,850
Consumption, estimated	2,000	[2]2,000	[2]2,000	[2]3,000	[2]3,000
Price, annual average, battery-grade lithium carbonate, dollars per metric ton[3]	6,800	6,690	6,500	8,650	13,900
Employment, mine and mill, number	70	70	70	70	70
Net import reliance[4] as a percentage of estimated consumption	>50	>25	>25	>50	>50

Recycling: Historically, lithium recycling has been insignificant but has increased steadily owing to the growth in consumption of lithium batteries. One domestic company has recycled lithium metal and lithium-ion batteries since 1992 at its facility in British Columbia, Canada. In 2009, the U.S. Department of Energy awarded $9.5 million to the company to construct the first U.S. recycling facility for lithium-ion vehicle batteries and, in 2015, the facility in Lancaster, OH, began operation.

Import Sources (2013–16): Chile, 49%; Argentina, 48%; China, 2%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Other alkali metals	2805.19.9000	5.5% ad val.
Lithium oxide and hydroxide	2825.20.0000	3.7% ad val.
Lithium carbonate:		
U.S. pharmaceutical grade	2836.91.0010	3.7% ad val.
Other	2836.91.0050	3.7% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: The Defense Logistics Agency Strategic Materials planned to acquire 600 kilograms of lithium cobalt oxide and 2,160 kilograms of lithium nickel cobalt aluminum oxide in FY 2018.

Stockpile Status—9–30–17[5]

Material	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Lithium cobalt oxide (kilograms, gross weight)	450	—	—
Lithium nickel cobalt aluminum oxide (kilograms, gross weight)	1,550	—	—

Events, Trends, and Issues: Worldwide lithium production increased by an estimated 13% to 43,000 tons in 2017 in response to increased lithium demand for battery applications. Consumption of lithium in 2017 was projected to be about 41,500 tons, up from 36,700 tons in 2016. Production in Australia increased by approximately 34% as two new spodumene operations ramped up production of concentrate throughout 2017. The leading lithium producers in Argentina, Australia, and Chile reported strong sales; however, heavy snowfall limited production at Argentina's new brine operation. Worldwide lithium production capacity was estimated to be 58,000 tons per year in 2016.

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LITHIUM

Spot lithium carbonate prices in China ranged from $15,000 to $24,000 per ton throughout the year owing to tight supply of imported spodumene from Australia. The rest of the world experienced more modest price increases owing to supplies available from more diversified sources of lithium. For large fixed contracts, Industrial Minerals reported an annual average U.S. lithium carbonate price of $13,900 per metric ton in 2017, a 61% increase from that of 2016.

Three spodumene operations in Australia and two brine operations each in Argentina and Chile accounted for the majority of world lithium production. Argentina's leading lithium producer expanded its lithium hydroxide production capacity by 80% in 2017 to meet increasing demand from the electric vehicle industry. The joint owners of the leading spodumene operation in Australia planned to double its spodumene concentrate production capacity to 1.34 million tons per year by mid-2019. To diversify supply, Chile's leading lithium producer announced a joint venture with a company in Australia to develop a spodumene operation. This follows a 2016 joint venture that the company in Chile established with a company in Argentina to develop a brine operation. Chile's two lithium producers each announced plans to build lithium hydroxide plants in Australia.

Lithium supply security has become a top priority for technology companies in the United States and Asia. 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 operations were under development in Argentina, Bolivia, Chile, China, and the United States; spodumene mining operations were under development in Australia, Austria, Canada, China, Czechia, Finland, Mali, Portugal, and Spain; a jadarite mining operation was under development in Serbia; and lithium-clay mining operations were under development in Mexico and the United States. Additional exploration for lithium continued, with numerous claims having been leased or staked worldwide.

World Mine Production and Reserves: Reserves for Australia and the United States were revised based on new information from Government and industry sources.

	Mine production		Reserves[6]
	2016	2017[e]	
United States	W	W	35,000
Argentina	5,800	5,500	2,000,000
Australia	14,000	18,700	[7]2,700,000
Brazil	200	200	48,000
Chile	14,300	14,100	7,500,000
China	2,300	3,000	3,200,000
Portugal	400	400	60,000
Zimbabwe	1,000	1,000	23,000
World total (rounded)	[8]38,000	[8]43,000	16,000,000

World Resources: Owing to continuing exploration, lithium resources have increased substantially worldwide and total more than 53 million tons. Identified lithium resources in the United States, from continental brines, geothermal brines, hectorite, oilfield brines, and pegmatites, have been revised to 6.8 million tons. Identified lithium resources in other countries have been revised to approximately 47 million tons. Identified lithium resources in Argentina are 9.8 million tons; Bolivia, 9 million tons; Chile, 8.4 million tons; China, 7 million tons; Australia, 5 million tons; Canada, 1.9 million tons; Congo (Kinshasa), Russia, and Serbia, 1 million tons each; Czechia, 840,000 tons; Zimbabwe, 500,000 tons; Spain, 400,000 tons; Mali, 200,000 tons; Brazil and Mexico, 180,000 tons each; Portugal, 100,000 tons; and Austria, 50,000 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]Source: Rockwood Holdings, Inc., 2014, 2013 annual report: Princeton, NJ, Rockwood Holdings, Inc., p. 16.
[2]Defined as production + imports – exports. Rounded to one significant digit to avoid disclosing company proprietary data.
[3]Source: Industrial Minerals, IM prices: Lithium carbonate, large contracts, delivered continental United States.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[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 reserves were about 1.4 million tons
[8]Excludes U.S. production.

MAGNESIUM COMPOUNDS[1]

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

Domestic Production and Use: Seawater and natural brines accounted for about 70% of U.S. magnesium compound production in 2017. The value of production of all types of magnesium compounds was estimated to be $250 million. Magnesium oxide and other 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 mined olivine and processed it for use as foundry sand. About 60% of the magnesium compounds consumed in the United States were used in agricultural, chemical, construction, environmental, and industrial applications in the form of caustic-calcined magnesia, magnesium chloride, magnesium hydroxide, and magnesium sulfates. The remaining 40% was used for refractories in the form of dead-burned magnesia, fused magnesia, and olivine.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production (shipments)	280	285	280	292	330
Shipments (gross weight)	425	435	424	441	490
Imports for consumption	439	515	621	401	400
Exports	71	79	83	99	110
Consumption, apparent[3]	648	721	818	594	620
Employment, plant, number[e]	250	250	260	260	260
Net import reliance[4] as a percentage of apparent consumption	57	60	66	51	47

Recycling: Some magnesia-based refractories are recycled, either for reuse as refractory material or for use as construction aggregate.

Import Sources (2013–16): Caustic-calcined magnesia: China, 49%; Canada, 20%; Australia, 11%; Brazil, 11%; and other, 9%. Dead-burned and fused magnesia: China, 56%; Brazil, 25%; Ukraine, 6%; Turkey, 6%; and other, 7%. Magnesium chloride: Israel, 62%; Netherlands, 28%; China, 3%; India, 2%; and other, 5%. Magnesium hydroxide: Mexico, 32%; Israel, 21%; Austria, 19%; Netherlands, 12%; and other, 16%. Magnesium sulfates: China, 76%; Germany, 19%; Canada, 2%; Mexico, 2%; and other, 1%.

Tariff:[5] Item	Number	Normal Trade Relations 12–31–17
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	2816.10.0000	3.1% ad val.
Magnesium chloride	2827.31.0000	1.5% ad val.
Magnesium sulfate (synthetic)	2833.21.0000	3.7% ad val.

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: Global consumption of dead-burned and fused magnesia increased by about 5% during the first 8 months of 2017 compared with that in the same period of 2016, as world steel production increased in 2017. Prices for dead-burned magnesia and caustic-calcined magnesia increased as steel production increased, despite abundant supplies from China. Consumption of dead-burned and fused magnesia increased slightly in the United States in 2017 and was expected to increase at a gradual rate in the foreseeable future.

Consumption of caustic-calcined magnesia continued to increase for animal feed supplements and fertilizer as the importance of magnesium as a nutrient gained recognition. Environmental applications, such as wastewater treatment, also accounted for increasing consumption of magnesium compounds, including caustic-calcined magnesia and magnesium hydroxide.

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MAGNESIUM COMPOUNDS

At the end of 2016, China eliminated its quotas on magnesia exports. This action was not expected to result in increased exports in the near term as magnesia exports in previous years have been below quota levels. A small amount of production capacity closed at magnesia plants in China during the first part of 2017; however, stronger enforcement of environmental regulations by the Government of China resulted in more shutdowns in the second half of the year, but employment concerns limited shutdowns at the Provincial level in China. Particularly, the magnesia industry in Liaoning Province (the leading magnesia-producing Province) was still generally composed of companies with small capacities and obsolete equipment.

Although magnesia from North Korea has been sold in China for many years, imports from North Korea were restricted by the Government of China in 2017. Significant price increases were reported for magnesia exports from China during the second half of 2017. With lower production in China and reduced imports to China from North Korea, decreased supplies and increased prices were expected to continue.

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

	Mine production		Reserves[7]
	2016	2017[e]	
United States	W	W	35,000
Australia	425	450	[8]320,000
Austria	710	730	50,000
Brazil	1,100	1,200	390,000
China	18,600	18,000	1,000,000
Greece	400	400	280,000
India	317	300	90,000
Korea, North	700	300	1,500,000
Russia	1,300	1,300	2,300,000
Slovakia	560	570	120,000
Spain	300	310	35,000
Turkey	2,700	2,700	230,000
Other countries	770	770	1,400,000
World total (rounded)	[9]27,900	[9]27,000	7,800,000

World Resources: 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 12 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. As serpentine could be used as a source of magnesia, a project in Canada was exploring a method to produce magnesia from serpentine in tailings of an asbestos mine in Quebec.

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

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]See also Magnesium Metal.
[2]Previously reported as magnesium content. Based on input from consumers, producers, and others involved in the industry, it was determined that reporting magnesium compound data in terms of contained magnesia was more useful than reporting in terms of magnesium content. Conversion factors used: magnesite, 47.8% MgO; magnesium chloride, 42.3% MgO; magnesium hydroxide, 69.1% MgO; and magnesium sulfate, 33.5% MgO.
[3]Defined as shipments + imports – exports.
[4]Defined as imports – exports + adjustments for industry stock changes.
[5]Tariffs are based on gross weight.
[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 reserves were about 38 million tons.
[9]Excludes U.S. production.

MAGNESIUM METAL[1]

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2017, primary magnesium was produced by one company in Utah at an electrolytic process plant that recovered magnesium from brines from the Great Salt Lake. Secondary magnesium was recovered from scrap at plants that produced magnesium ingot and castings, and from aluminum alloy scrap at secondary aluminum smelters. Primary magnesium production in 2017 was estimated to have decreased from that of 2016. Information regarding U.S. primary magnesium production was withheld to avoid disclosing company proprietary data. The leading use for primary magnesium metal, which accounted for 34% of reported consumption, was in aluminum-base alloys that were used for packaging, transportation, and other applications. Castings accounted for 30% of primary magnesium metal consumption, desulfurization of iron and steel, 22%; wrought products, 6%; and other uses, 8%. Consumption of magnesium as a reducing agent for metals production decreased dramatically compared with that in 2016 because of the shutdown of a titanium sponge producer in Utah at the end of 2016. About 52% of the secondary magnesium was consumed for structural uses and about 48% was used in aluminum alloys.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Primary	W	W	W	W	W
Secondary (new and old scrap)	79	81	88	96	120
Imports for consumption	47	54	51	47	43
Exports	16	17	15	19	15
Consumption:					
Reported, primary	66	64	64	47	40
Apparent[2]	W	W	W	W	W
Price, yearend:					
U.S. spot Western, dollars per pound, average	2.13	2.15	2.15	2.15	2.15
China, free on board, dollars per metric ton, average	2,615	2,325	1,825	2,390	2,220
Stocks, producer, yearend	W	W	W	W	W
Employment, number[e]	420	420	420	420	400
Net import reliance[3] as a percentage of apparent consumption	<50	<50	<50	<50	<25

Recycling: In 2017, about 23,000 tons of secondary magnesium was recovered from old scrap and 97,000 tons were recovered from new scrap. Aluminum-base alloys accounted for 52% of the secondary magnesium recovered, and magnesium-based castings, ingot, and other materials accounted for about 48%.

Import Sources (2013–16): Israel, 27%; Canada, 22%; China, 10%; United Kingdom, 8%; and other, 33%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Unwrought metal	8104.11.0000	8.0% ad val.
Unwrought alloys	8104.19.0000	6.5% ad val.
Scrap	8104.20.0000	Free.
Powders and granules	8104.30.0000	4.4% ad val.
Wrought metal	8104.90.0000	14.8¢/kg on Mg content + 3.5% ad val.

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

Government Stockpile: None.

Events, Trends, and Issues: The sole U.S. producer of primary magnesium temporarily shut down some capacity at the end of 2016 citing the shutdown of a titanium sponge plant that had been a major customer, and this capacity was not expected to restart in the foreseeable future.

In China, a new 100,000-ton-per-year plant in Qinghai Province that would produce magnesium from lake brines was completed in 2017 and was expected to ramp up to full capacity in early 2018. Some plants producing magnesium using the Pidgeon (silicothermic reduction) process were expected to shut down, owing to energy cost increases and to comply with environmental regulations ordered by the Government of China.

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MAGNESIUM METAL

Producers in China dominate magnesium production, but several projects were under development to increase primary magnesium metal capacity elsewhere. One company conducted laboratory testing to recover magnesium from its dolomite deposit in Nevada and was planning to conduct a feasibility study for a proposed plant. In May, a company in Quebec, Canada, started production of magnesium from serpentine contained in asbestos tailings at its 200-ton-per-year pilot plant and was planning to construct a 50,000-ton-per-year plant. Another company was testing its process for producing magnesium from serpentine-bearing asbestos tailings in the same region of Quebec. A company in Australia was conducting a feasibility study for a 5,000-ton-per-year plant to recover magnesium from coal fly ash.

The use of magnesium in automobile parts continued to increase as automobile manufacturers sought to decrease vehicle weight in order to comply with fuel-efficiency standards. Magnesium castings have substituted for aluminum, iron, and steel in some automobiles. The substitution of aluminum for steel in automobile sheet was expected to increase consumption of magnesium in aluminum alloy sheet. Although some magnesium sheet applications have been developed for automobiles, these were generally limited to expensive sports cars and luxury vehicles, automobiles where the higher price of magnesium is not a deterrent to its use.

World Primary Production and Reserves:

	Primary production	
	2016	2017[e]
United States	W	W
Brazil	16	16
Canada	—	([5])
China	871	930
Iran	2	5
Israel	23	24
Kazakhstan	10	10
Korea, Republic of	10	10
Russia	58	60
Turkey	5	15
Ukraine	5	8
World total (rounded)	[6]1,000	[6]1,100

Reserves[4]

Magnesium metal is derived from seawater, natural brines, dolomite, serpentine, and other minerals. The reserves for this metal are sufficient to supply current and future requirements.

World Resources: 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 Magnesium Compounds.
[2]Defined as primary production + secondary production from old scrap + imports – exports + adjustments for industry stock changes.
[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]Less than ½ unit.
[6]Excludes U.S. production.

MANGANESE

(Data in thousand metric tons gross weight unless otherwise noted)

Domestic Production and Use: Manganese ore containing 20% or more manganese has not been produced domestically since 1970. Manganese ore was consumed mainly by eight firms with plants principally in the East and Midwest. Most ore consumption was related to steel production, either directly in pig iron manufacture or indirectly through upgrading the ore to ferroalloys. Additional quantities of ore were used for such nonmetallurgical purposes as production of dry cell batteries, in fertilizers and animal feed, and as a brick colorant. Manganese ferroalloys were produced at two plants. Construction, transportation, and machinery end uses accounted for about 37%, 15%, and 12%, respectively, of manganese consumption on a manganese-content basis. Most of the rest went to a variety of other iron and steel applications. In 2017, the value of domestic consumption, estimated from foreign trade data on a manganese-content basis, was about $940 million.

Salient Statistics—United States:[1]	2013	2014	2015	2016	2017[e]
Production, mine	—	—	—	—	—
Imports for consumption:					
Manganese ore	558	387	441	282	310
Ferromanganese	335	365	292	229	300
Silicomanganese[2]	329	448	301	264	370
Exports:					
Manganese ore	1	1	1	1	2
Ferromanganese	2	6	5	7	9
Silicomanganese	6	3	1	2	8
Shipments from Government stockpile excesses[3]					
Manganese ore	—	—	—	—	—
Ferromanganese	1	18	32	42	11
Consumption, reported:[4]					
Manganese ore	523	508	451	410	390
Ferromanganese	368	360	344	342	360
Silicomanganese	152	146	138	139	150
Consumption, apparent, manganese[5]	801	834	693	538	660
Price, average, 46% to 48% Mn metallurgical ore, dollars per metric ton unit, contained Mn:					
Cost, insurance, and freight (c.i.f.), U.S. ports[e]	4.61	4.49	3.53	3.41	4.40
China spot market (c.i.f.)	5.29	4.72	3.22	4.48	[6]5.88
Stocks, producer and consumer, yearend:[4]					
Manganese ore	217	189	187	207	200
Ferromanganese	27	23	21	21	22
Silicomanganese	6	10	21	10	10
Net import reliance[7] as a percentage of apparent consumption	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 (2013–16): Manganese ore: Gabon, 73%; South Africa, 11%; Australia, 9%; Mexico, 3%; and other, 4%. Ferromanganese: South Africa, 51%; Australia, 15%; Norway, 12%; Republic of Korea, 11%; and other, 11%. Silicomanganese: Georgia, 31%; South Africa, 25%; Australia, 19%; Norway, 9%; and other, 16%. Manganese contained in principal manganese imports:[8] South Africa, 29%; Gabon, 22%; Australia, 14%; Georgia, 11%; and other, 24%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Ores and concentrates	2602.00.0040/60	Free.
Manganese dioxide	2820.10.0000	4.7% ad val.
High-carbon ferromanganese	7202.11.5000	1.5% ad val.
Ferrosilicon manganese (silicomanganese)	7202.30.0000	3.9% ad val.
Metal, unwrought	8111.00.4700/4900	14% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

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MANGANESE

Government Stockpile:

Stockpile Status—9–30–17[9]

Material	Inventory	Authorized for disposal	Disposals FY 2017
Manganese ore, metallurgical grade	292	292	—
Ferromanganese, high-carbon	213	45	24

Events, Trends, and Issues: U.S. manganese apparent consumption was estimated to increase by 23% to 660,000 tons in 2017 compared with that in 2016. This was primarily a result of increases in U.S. ferromanganese and silicomanganese imports in response to the 4% increase in domestic steel production. The annual average domestic manganese ore contract price followed the 28% increase in the average U.S. import unit value of manganese ore imports containing 47% or more manganese. This increase in price reflected the decrease in manganese ore production worldwide during 2016 and the early part of 2017, particularly from several large producers in Australia, Gabon, and South Africa.

World Mine Production and Reserves (manganese content): Reserves for Australia, China, Gabon, Ghana, and India were revised based on data reported by the Governments of those countries.

	Mine production 2016	Mine production 2017[e]	Reserves[10]
United States	—	—	—
Australia	2,240	2,200	[11]94,000
Brazil	1,080	1,200	120,000
China	2,330	2,500	48,000
Gabon	1,620	1,600	20,000
Ghana	553	550	13,000
India	745	790	34,000
Kazakhstan, concentrate	212	230	5,000
Malaysia	266	270	NA
Mexico	206	220	5,000
South Africa	5,300	5,300	200,000
Ukraine, concentrate	425	380	140,000
Other countries	681	760	Small
World total (rounded)	15,700	16,000	680,000

World Resources: 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 about 78% of the world's identified manganese resources, and Ukraine accounts for about 10%.

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]Imports more nearly represent amount consumed than does reported consumption.
[3]Defined as stockpile shipments – receipts. If receipts, a negative quantity is shown.
[4]Exclusive of ore consumed directly at iron and steel plants and associated yearend stocks.
[5]Defined as imports – exports + adjustments for Government and industry stock changes, thousand tons, manganese content. To avoid double counting, manganese consumption is not calculated as the sum of manganese ore, ferromanganese, and silicomanganese consumption because manganese in ore is used to produce ferromanganese and silicomanganese.
[6]Average weekly price through October 2017 for average metallurgical-grade ore containing 44% manganese, as reported by CRU Group.
[7]Defined as imports – exports + adjustments for Government and industry stock changes.
[8]Includes imports of ferromanganese, manganese ore, silicomanganese, synthetic manganese dioxide, and unwrought manganese metal.
[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 reserves were about 47 million tons of manganese content.

MERCURY

(Data in metric tons of mercury content unless otherwise noted)

Domestic Production and Use: Mercury has not been produced as a principal mineral commodity in the United States since 1992. In 2017, 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. It was estimated that less than 40 tons per year of mercury was consumed domestically. The leading domestic end users of mercury were the chlorine-caustic soda (chloralkali), dental, electronics, and fluorescent-lighting manufacturing industries. Only two mercury cell chloralkali plants operated in the United States in 2017. 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.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production:					
Mine (byproduct)	NA	NA	NA	NA	NA
Secondary	NA	NA	NA	NA	NA
Imports for consumption (gross weight), metal	38	49	26	24	15
Exports (gross weight), metal	([1])	—	([1])	—	—
Price, average value, dollars per flask 99.99%, European Union[2, 3]	3,412	3,037	1,954	1,402	1,000
Net import reliance[4] as a percentage of apparent consumption	E	NA	NA	NA	NA

Recycling: In 2017, eight facilities operated by six companies in the United States accounted for the majority of secondary mercury produced and were authorized by the U.S Department of Energy to temporarily store mercury. 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 phasing out of compact and traditional fluorescent lighting for light-emitting-diode (LED) lighting, there has been an increased amount of mercury being recycled.

Import Sources (2013–16): Canada, 41%; Germany, 37%; France, 10%; Switzerland, 6%; and other, 6%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Mercury	2805.40.0000	1.7% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: An inventory of 4,436 tons of mercury was held in storage at the Hawthorne Army Depot, in Hawthorne, NV. The Mercury Export Ban Act of 2008 required the U.S. Department of Energy to establish long-term management and storage capabilities for domestically produced elemental mercury. Sales of mercury from the stockpiles remained suspended.

Stockpile Status—9–30–17[5]

Material	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Mercury	4,436	—	—

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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. Mercury continues to be released to the environment from numerous sources, including mercury-containing car switches when automobiles are scrapped without recovering them for recycling, coal-fired powerplant emissions, and incineration of mercury-containing medical devices. Mercury is no longer used in 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 small-scale mining operations. Conversion to non-mercury 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, storage.

Byproduct mercury production is expected to continue from large-scale domestic and foreign gold-silver mining and processing, as is secondary production of mercury from an ever-diminishing supply of mercury-containing products. The quantity of byproduct mercury entering the global supply from foreign gold-silver processing may fluctuate dramatically from year to year because mercury is frequently stockpiled in producing countries. 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, such as digital thermometers, and in measuring, control, and dental applications.

World Mine Production and Reserves:

	Mine production[e]		Reserves[6]
	2016	2017	
United States	NA	NA	Quantitative estimates of reserves are not available. China, Kyrgyzstan, and Peru are thought to have the largest reserves.
China	2,000	2,000	
Kyrgyzstan	50	50	
Mexico (exports)	300	300	
Peru (exports)	40	40	
Tajikistan	30	30	
Other countries	60	60	
World total (rounded)	2,500	2,500	

World Resources: 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, there are mercury occurrences in Alaska, Arkansas, California, Nevada, and Texas; however, mercury has not been mined as a principal mineral commodity since 1992. 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. "Galistan," 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 have been substituted for mercury fungicides in latex paint.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Less than ½ unit.
[2]Some international data and dealer prices are reported in flasks. One metric ton (1,000 kilograms) = 29.0082 flasks, and 1 flask = 76 pounds, or 34.5 kilograms, or 0.035 ton.
[3]Average annual price of minimum 99.99% mercury published by Argus Media group–Argus Metals International.
[4]Defined as imports – exports + adjustments for Government stock changes.
[5]See Appendix B for definitions.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.

MICA (NATURAL)

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Scrap and flake mica production, excluding low-quality sericite, was estimated to be 31,700 tons valued at $3 million. Mica was mined in Georgia, North Carolina, and South Dakota. Scrap mica was recovered principally from mica and sericite schist and as a byproduct from feldspar, industrial sand beneficiation, and kaolin. Nine companies produced an estimated 67,000 tons of ground mica valued at about $20 million from domestic and imported scrap and flake mica. The majority of 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 was produced as incidental production from feldspar mining in the Spruce Pine area of North Carolina. 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:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Scrap and flake:					
Production:[1, 2]					
Mine	48,100	48,200	32,600	30,900	31,700
Ground	79,200	79,400	53,700	68,100	67,000
Imports[3]	30,900	33,400	33,200	31,500	30,300
Exports[4]	6,380	7,900	7,380	6,230	7,100
Consumption, apparent[5]	72,600	73,700	58,400	56,200	54,900
Price, average, dollars per metric ton, reported:					
Scrap and flake	124	117	142	107	125
Ground:					
Dry	279	285	290	262	270
Wet	360	369	375	321	350
Employment, mine, number	NA	NA	NA	NA	NA
Net import reliance[6] as a percentage of apparent consumption	34	35	44	45	42
Sheet:					
Production, mine[e]	([7])	([7])	([7])	([7])	([7])
Imports[8]	1,910	2,470	2,130	2,060	2,000
Exports[9]	1,150	1,070	968	803	800
Consumption, apparent[5]	760	1,400	1,160	1,260	1,200
Price, average value, dollars per kilogram, muscovite and phlogopite mica, reported:					
Block	129	148	133	130	130
Splittings	1.72	1.70	1.76	1.57	1.60
Stocks, fabricator and trader, yearend	NA	NA	NA	NA	NA
Net import reliance[6] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2013–16): Scrap and flake: Canada, 44%; China, 32%; India, 13%; Finland, 4%; and other, 7%. Sheet: China, 43%; Brazil, 26%; Belgium, 10%; Austria, 6%; and other, 15%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Crude mica and mica rifted into sheets or splittings	2525.10.0000	Free.
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 reconstructed mica	6814.10.0000	2.7% ad val.
Worked mica and articles of mica, other	6814.90.0000	2.6% ad val.

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MICA (NATURAL)

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic production of scrap and flake mica was estimated to have increased slightly in 2017. Apparent consumption of scrap and flake mica decreased slightly because of an increase in exports and a decrease in imports. Apparent consumption of sheet mica was estimated to have decreased by 5% in 2017. No environmental concerns are associated with the manufacture and use of mica products. Future supplies of mica for United States consumption were expected to come increasingly from imports, primarily from Brazil, Canada, China, India, and Finland.

World Mine Production and Reserves: Production of scrap and flake mica in China was revised downward significantly for the past several years owing to new information from a Government source. Output from China had previously been estimated at 785,000 tons per year. Most United States mica imports from China were for powder, which can be from mined, recycled, or stockpiled mica. This has changed the world production totals from approximately 1 million tons to 300,000 tons. Finland is the leading global producer of natural mica, accounting for 22% of estimated worldwide production.

	Scrap and flake			Sheet		
	Mine production[e]		Reserves[10]	Mine production[e]		Reserves[10]
	2016	2017		2016	2017	
All types:						
United States[1]	30,900	31,700	Large	(7)	(7)	Very small
Canada	20,000	22,000	Large	NA	NA	NA
China	25,000	25,000	Large	NA	NA	NA
Finland	63,000	65,000	Large	NA	NA	NA
France	20,000	20,000	Large	NA	NA	NA
India	14,000	14,000	Large	1,000	1,000	Very large
Korea, Republic of	18,000	19,000	Large	—	—	NA
Madagascar	18,000	18,000	Large	—	—	NA
Turkey	40,000	40,000	Large	—	—	NA
Other countries	46,000	43,000	Large	200	200	Moderate
World total (rounded)	295,000	300,000	Large	1,200	1,200	Very large

World Resources: 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 are uneconomic 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 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, styrene, vinyl-PVC, 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. — Zero.
[1]Sold or used by producing companies.
[2]Excludes low-quality sericite used primarily for brick manufacturing.
[3]Includes Harmonized Tariff Schedule codes: 2525.10.0050, <$1.00/kg; 2525.20.0000; and 2525.30.0000.
[4]Includes Schedule B numbers: 2525.10.0000, <$1.00/kg; 2525.20.0000; and 2525.30.0000.
[5]Defined as mine production + imports – exports.
[6]Defined as imports – exports.
[7]Less than ½ unit.
[8]Includes Harmonized Tariff Schedule codes: 2525.10.0010; 2525.10.0020; 2525.10.0050, >$1.00/kg; 6814.10.0000; and 6814.90.0000.
[9]Includes Schedule B numbers: 2525.10.0000, >$1.00/kg; 6814.10.0000; and 6814.90.0000.
[10]See Appendix C for resource and reserve definitions and information concerning data sources.

MOLYBDENUM

(Data in metric tons of molybdenum content unless otherwise noted)

Domestic Production and Use: U.S. mine production of molybdenum in 2017 increased by 25% to about 44,600 tons, and was valued at about $800 million (based on an average oxide price). Molybdenum ore was produced as a primary product at two mines—both in Colorado—whereas seven copper mines (four in Arizona and one each in Montana, Nevada, and Utah) recovered molybdenum as a byproduct. Three roasting plants converted molybdenite concentrate to molybdic oxide, from which intermediate products, such as ferromolybdenum, metal powder, and various chemicals, were produced. Metallurgical applications accounted for about 87% of the total molybdenum consumed.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, mine	61,000	68,200	47,400	35,800	44,600
Imports for consumption	20,300	25,300	17,500	22,800	38,200
Exports	53,100	65,200	41,400	31,200	42,600
Consumption:					
Reported[1]	18,600	19,500	17,600	16,700	17,000
Apparent[2]	29,800	28,000	23,800	27,300	40,200
Price, average value, dollars per kilogram[3]	22.85	25.84	15.10	14.40	18.00
Stocks, consumer materials	1,820	2,010	1,880	1,940	1,950
Employment, mine and plant, number	960	1,000	950	920	940
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 comprises revert scrap, and 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. Molybdenum is not recovered separately from recycled steel and superalloys, but the molybdenum content of the recycled alloys is significant, and the molybdenum content is reused. Recycling of molybdenum-bearing scrap will continue to be dependent on the markets for the principal alloy metals in which molybdenum is contained, such as iron, nickel, and chromium.

Import Sources (2013–16): Ferromolybdenum: Chile, 73%; Canada, 12%; Republic of Korea, 9%; and other, 6%. Molybdenum ores and concentrates: Peru, 35%; Chile, 27%; Canada, 23%; Mexico, 14%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Molybdenum ore and concentrates, roasted	2613.10.0000	12.8¢/kg + 1.8% ad val.
Molybdenum ore and concentrates, other	2613.90.0000	17.8¢/kg.
Molybdenum chemicals:		
Molybdenum oxides and hydroxides	2825.70.0000	3.2% ad val.
Molybdates of ammonium	2841.70.1000	4.3% ad val.
Molybdates, all others	2841.70.5000	3.7% ad val.
Molybdenum pigments, molybdenum orange	3206.20.0020	3.7% ad val.
Ferroalloys, ferromolybdenum	7202.70.0000	4.5% ad val.
Molybdenum metals:		
Powders	8102.10.0000	9.1¢/kg + 1.2% ad val.
Unwrought	8102.94.0000	13.9¢/kg + 1.9% ad val.
Wrought bars and rods	8102.95.3000	6.6% ad val.
Wrought plates, sheets, strips, etc.	8102.95.6000	6.6% ad val.
Wire	8102.96.0000	4.4% ad val.
Waste and scrap	8102.97.0000	Free.
Other	8102.99.0000	3.7% ad val.

Depletion Allowance: 22% (Domestic); 14% (Foreign).

Government Stockpile: None.

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MOLYBDENUM

Events, Trends, and Issues: In 2017, the average molybdic oxide price was 25% higher than that of 2016 and U.S. estimated mine output of molybdenum increased by 25% from that of 2016. The increase in production was seen at both primary and byproduct mines. Primary molybdenum production continued at the Climax Mine in Lake County and Summit County, CO, and at the Henderson Mine in Clear Creek County, CO, but primary production at the Ashdown Mine in Humboldt County, NV, and at the Questa Mine in Taos County, NM, continued to be suspended. The Thompson Creek Mine in Custer County, ID, and the Mineral Park Mine in Mohave County, AZ, continued to be on care-and-maintenance status in 2017.

U.S. imports for consumption increased by 68% from those of 2016. The large increase in 2017 was attributed mainly to the 75% increase of imports of molybdenum ores and concentrates and as well as FeMo imports more than doubling compared with 2016. U.S. exports increased by 37% from those of 2016 mainly owing to an increase in exports of molybdenum ores and concentrates and molybdates. Apparent consumption increased by 26% from that of 2016.

Global molybdenum production in 2017 increased by 4% compared with 2016. In descending order of production, China, Chile, the United States, Peru, Mexico, and Armenia provided approximately 95% of total global production.

World Mine Production and Reserves: The reserves estimate for Canada was revised based on new information from the Mining Association of Canada. The reserves estimate for Peru was revised based on new information from the Ministry of Energy and Mines of Peru. The reserves estimates for Argentina and Russia was revised based on company reports.

	Mine production		Reserves[5]
	2016	2017[e]	(thousand tons)
United States	35,800	44,600	2,700
Argentina	800	800	100
Armenia	6,300	6,300	150
Canada	2,710	3,000	150
Chile	55,600	58,000	1,800
China[e]	130,000	130,000	8,300
Iran	3,500	3,500	43
Mexico	11,900	12,000	130
Mongolia	2,440	2,400	160
Peru	25,800	26,000	2,200
Russia[e]	3,000	3,000	1,000
Turkey	900	900	100
Uzbekistan[e]	450	450	60
World total (rounded)	279,000	290,000	17,000

World Resources: 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.

[1]Reported consumption of primary molybdenum products.

[2]Defined as production + net import reliance.

[3]Time-weighted average price per kilogram of molybdenum contained in technical-grade molybdic oxide, as reported by CRU Group.

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

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

NICKEL

(Data in metric tons of nickel content unless otherwise noted)

Domestic Production and Use: In 2017, the underground Eagle Mine in Michigan produced approximately 23,000 tons of nickel in concentrate. The concentrates were exported to smelters in Canada and overseas for processing. Nickel in crystalline sulfate was produced as a byproduct of smelting and refining platinum-group-metal ores mined in Montana. The principal nickel-consuming States were Pennsylvania and Kentucky. Approximately 48% of the primary nickel consumed went into stainless and alloy steel products, 40% into nonferrous alloys and superalloys, 8% into electroplating, and 4% into other uses.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Mine	—	4,300	27,200	24,100	23,000
Refinery, byproduct	W	W	W	W	W
Shipments of purchased scrap[1]	124,000	109,000	116,000	121,000	120,000
Imports:					
Ores and concentrates	3	92	24	([2])	—
Primary	126,000	156,000	130,000	111,000	150,000
Secondary	26,300	39,000	27,100	32,300	37,000
Exports:					
Ores and concentrates	1,010	3,320	25,400	22,400	23,800
Primary	10,600	10,400	9,600	10,300	11,000
Secondary	61,100	56,300	51,900	63,700	48,000
Consumption:					
Reported, primary metal	107,000	113,000	106,000	99,000	110,000
Reported, secondary	89,100	91,500	90,600	89,900	90,000
Apparent, primary metal[3]	114,000	149,000	121,000	105,000	140,000
Apparent, total[4]	203,000	240,000	211,000	195,000	230,000
Price, average annual, London Metal Exchange (LME):					
Cash, dollars per metric ton	15,018	16,865	11,831	9,594	10,144
Cash, dollars per pound	6.812	7.650	5.367	4.352	4.601
Stocks:					
Consumer, yearend	18,400	23,300	19,200	15,300	15,000
LME U.S. warehouses	3,948	1,560	4,212	5,232	4,200
Net import reliance[5] as a percentage of total apparent consumption	47	58	52	45	59

Recycling: In 2017, approximately 90,000 tons of nickel was recovered from purchased scrap. This represented about 39% of consumption for the year.

Import Sources (2013–16): Canada, 42%; Norway, 10%; Australia, 7%; Russia, 7%; and other, 34%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Nickel ores and concentrates	2604.00.0040	Free.
Nickel oxides, chemical grade	2825.40.0000	Free.
Ferronickel	7202.60.0000	Free.
Unwrought nickel, not alloyed	7502.10.0000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

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NICKEL

Government Stockpile: The U.S. Government sold the last of the nickel in the National Defense Stockpile in 1999. The U.S. Department of Energy is holding 8,800 tons of nickel ingot contaminated by low-level radioactivity at Paducah, KY, plus 5,080 tons of contaminated shredded nickel scrap at Oak Ridge, TN. Ongoing decommissioning activities at former nuclear defense sites were expected to generate an additional 20,000 tons of nickel in scrap.

Events, Trends, and Issues: The U.S. steel industry produced approximately 2.0 million tons of austenitic (nickel-bearing) stainless steel in 2017. Stainless steel has traditionally accounted for two-thirds of primary nickel use worldwide, with more than one-half of the steel going into the construction, food processing, and transportation sectors.

World production was essentially unchanged in 2017. Production decreased in several leading producing countries including Australia, Brazil, Canada, and the Philippines. The largest decrease in production took place in the Philippines, owing to the continued suspension of as many as one-half of the country's mining operations for failing to meet environmental standards. These decreases were offset primarily by increased production in Indonesia, which in January eased an export ban on direct-shipping ore for companies that intend to construct nickel-processing facilities.

World Mine Production and Reserves: Reserves for Brazil, Canada, China, New Caledonia, and the United States were revised based on new information from company or Government reports.

	Mine production		Reserves[6]
	2016	2017[e]	
United States	24,100	23,000	130,000
Australia	204,000	190,000	[7]19,000,000
Brazil	160,000	140,000	12,000,000
Canada	236,000	210,000	2,700,000
China	98,000	98,000	2,900,000
Colombia	41,600	49,000	1,100,000
Cuba	51,600	51,000	5,500,000
Guatemala	54,000	68,000	1,800,000
Indonesia	199,000	400,000	4,500,000
Madagascar	49,000	45,000	1,600,000
New Caledonia[8]	207,000	210,000	—
Philippines	347,000	230,000	4,800,000
Russia	222,000	180,000	7,600,000
South Africa	49,000	49,000	3,700,000
Other countries	150,000	150,000	6,500,000
World total (rounded)	2,090,000	2,100,000	74,000,000

World Resources: Identified land-based resources averaging 1% nickel or greater contain at least 130 million tons of nickel, with about 60% in laterites and 40% in sulfide deposits. Extensive nickel resources also are found in manganese crusts and nodules on the ocean floor. The decline in discovery of new sulfide deposits in traditional mining districts has led to exploration in more challenging locations such as east-central Africa and the subarctic.

Substitutes: Low-nickel, duplex, or ultrahigh-chromium stainless steels are being 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. Lithium-ion batteries may be used instead of nickel metal hydride batteries in certain applications.

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

[1]Scrap receipts – shipments by consumers + exports – imports + adjustments for consumer stock changes.

[2]Less than ½ unit

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

[4]Apparent primary consumption + reported secondary consumption

[5]Defined as imports – exports + adjustments for consumer stock changes.

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

[7]For Australia, Joint Ore Reserves Committee-compliant reserves were about 6.0 million tons.

[9]Overseas territory of France. Although nickel-cobalt mining and processing continued, the leading producer reported zero reserves owing to recent nickel prices.

NIOBIUM (COLUMBIUM)

(Data in metric tons of niobium content unless otherwise noted)

Domestic Production and Use: Significant U.S. niobium mine production has not been reported since 1959. Domestic niobium resources are of low grade, some are mineralogically complex, and most are not commercially recoverable. Companies in the United States produced niobium-containing materials from imported niobium minerals, 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 reported niobium consumption was as follows: steels, about 76%, and superalloys, about 24%. In 2017, the estimated value of niobium consumption was $290 million, as measured by the value of imports.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, mine	—	—	—	—	—
Imports for consumption[e, 1]	8,580	11,100	8,520	9,580	11,300
Exports[e, 1]	435	1,110	1,430	841	1,500
Government stockpile releases[2]	—	—	—	—	—
Consumption:[e]					
Apparent[3]	8,140	10,000	7,080	8,740	9,800
Reported[4]	7,500	8,210	7,510	7,370	6,510
Unit value, ferroniobium, dollars per kilogram[5]	27	26	24	21	18
Net import reliance[6] 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 is not available, but it may be as much as 20% of apparent consumption.

Import Sources (2013–16): Niobium ore and concentrate: Brazil, 47%; Rwanda, 21%; Australia, 11%; Canada, 5%; and other, 16%. Niobium metal and oxide: Brazil, 73%; Canada, 19%; Russia, 3%; and other, 5%. Total imports: Brazil, 72%; Canada, 18%; Russia, 3%; and other, 7%. Of the U.S. niobium material imports, 93% (by gross quantity) was ferroniobium and niobium metal and oxide.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Synthetic tantalum-niobium concentrates	2615.90.3000	Free.
Niobium ores and concentrates	2615.90.6030	Free.
Niobium oxide	2825.90.1500	3.7% ad val.
Ferroniobium:		
Less than 0.02% P or S, or less than 0.4% Si	7202.93.4000	5% ad val.
Other	7202.93.8000	5% ad val.
Niobium:		
Waste and scrap[7]	8112.92.0600	Free.
Unwrought, powders	8112.92.4000	4.9% ad val.
Niobium, other[7]	8112.99.9000	4% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: In the annual materials plan for fiscal year (FY) 2018, the Defense Logistics Agency (DLA) Strategic Materials announced the 2018 maximum acquisition limit of 209 tons for ferroniobium. In FY 2017, 122 tons of ferroniobium was acquired for the stockpile. No disposals were planned.

Stockpile Status—9–30–17[8]

Material	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Ferroniobium	161	—	—
Niobium metal	10	—	—

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NIOBIUM (COLUMBIUM)

Events, Trends, and Issues: Niobium principally was imported in the form of ferroniobium. Based on data through August 2017, U.S. niobium apparent consumption (measured in contained niobium) was estimated to be 9,800 tons, 12% more than that of 2016. Brazil continued to be the world's leading niobium producer with 89% of global production, followed by Canada with 10%.

One domestic company continued to make progress with developing its Elk Creek project in Nebraska by receiving approval to continue initial planning and permitting. The project would be the only primary niobium processing facility in the United States and was expected to begin production after 2018.

In September 2016, a Chinese company acquired the niobium-phosphate business of a United Kingdom company. The niobium business was located in Goias State, Brazil, and consisted of the Boa Vista Mine, three processing facilities, two nonoperating mines, and two mineral deposits.

World Mine Production and Reserves:

	Mine production		Reserves[9]
	2016	2017[e]	
United States	—	—	—
Brazil	57,000	57,000	4,100,000
Canada	6,100	6,000	200,000
Other countries	800	800	NA
World total (rounded)	63,900	64,000	>4,300,000

World Resources: 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. The United States has approximately 150,000 tons of niobium in identified resources, most of which were considered subeconomic at 2017 prices for niobium.

Substitutes: The following materials can be substituted for niobium, but a performance loss or higher cost may ensue: molybdenum and vanadium, as alloying elements in high-strength low-alloy steels; tantalum and titanium, as alloying elements in stainless- and high-strength steels; and ceramics, molybdenum, tantalum, and tungsten in high-temperature applications.

[e]Estimated. NA Not available. — Zero.
[1]Imports and exports include the estimated niobium content of niobium and tantalum ores and concentrates, niobium oxide, ferroniobium, niobium unwrought alloys, metal, and powder.
[2]Government stockpile inventory reported by DLA Strategic Materials is the basis for estimating Government stockpile releases.
[3]Defined as imports – exports.
[4]Includes ferroniobium and nickel niobium.
[5]Unit value is mass-weighted average unit value of gross quantity of U.S. ferroniobium trade. (Trade is imports plus exports.)
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]This category includes materials other than niobium-containing material.
[8]See Appendix B for definitions.
[9]See Appendix C for resource and reserve definitions and information concerning data sources.

NITROGEN (FIXED)—AMMONIA

(Data in thousand metric tons of contained nitrogen unless otherwise noted)

Domestic Production and Use: Ammonia was produced by 15 companies at 32 plants in 16 States in the United States during 2017; 2 additional plants were idle for the entire year. About 50% of total U.S. ammonia production capacity was located in Louisiana, Oklahoma, and Texas because of their large reserves of natural gas, the dominant domestic feedstock for ammonia. In 2017, U.S. producers operated at about 75% of rated capacity. The United States was one of the world's leading producers and consumers of ammonia. Urea, ammonium nitrate, ammonium phosphates, nitric acid, and ammonium sulfate were, in descending order of importance, the major derivatives of ammonia produced in the United States.

Approximately 88% of apparent domestic ammonia consumption 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:	2013	2014	2015	2016	2017[e]
Production	[1]9,170	[1]9,330	[1]9,590	[1]10,200	10,500
Imports for consumption	4,960	4,150	4,320	3,840	3,300
Exports	196	111	93	182	530
Consumption, apparent[2]	13,900	13,300	13,700	13,900	13,300
Stocks, producer, yearend	240	280	420	400	410
Price, dollars per short ton, average, f.o.b. Gulf Coast[3]	541	531	481	267	240
Employment, plant, number[e]	1,200	1,200	1,200	1,300	1,500
Net import reliance[4] as a percentage of apparent consumption	34	30	30	26	21

Recycling: None.

Import Sources (2013–16): Trinidad and Tobago, 63%; Canada, 21%; Russia, 5%; Ukraine, 4%; and other, 7%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Ammonia, anhydrous	2814.10.0000	Free.
Urea	3102.10.0000	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 about $2.44 and $3.42 per million British thermal units for most of the year, with an average of about $3.00 per million British thermal units. Natural gas prices in 2017 were relatively stable; slightly higher prices were a result of increased demand for natural gas owing to cold temperatures and associated increased demand for power generation. The U.S. Department of Energy, Energy Information Administration, projected that Henry Hub natural gas spot prices would average $3.10 per million British thermal units in 2018.

The weekly average Gulf Coast ammonia price was $257 per short ton at the beginning of 2017 and decreased to $235 per short ton in October. The average ammonia price for 2017 was estimated to be about $240 per short ton. Decreased demand for ammonia globally has resulted in the lower fertilizer prices in 2017.

A long period of stable and low natural gas prices in the United States has made it economical for companies to upgrade existing ammonia plants and plan for the construction of new nitrogen projects. During the next 4 years, it is expected that about 2.5 million tons of annual production capacity will be added in the United States. The additional capacity will reduce, but likely not eliminate, ammonia imports. In 2016, upgrades to increase ammonia capacity came on line as well as one new ammonia plant in Arkansas. In 2017, two new ammonia facilities in Iowa and Louisiana became operational.

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NITROGEN (FIXED)—AMMONIA

Global ammonia capacity is expected to increase by 8% during the next 4 years. In addition to North America, capacity additions are expected in Africa, Central Asia, and Eastern Europe. Increased demand for ammonia is expected in Latin America and South Asia as a result of regional nitrogen deficits.

Large corn plantings increase the demand for nitrogen fertilizers. According to the U.S. Department of Agriculture, U.S. corn growers planted 36.4 million hectares of corn in the 2017 crop year (July 1, 2016, through June 30, 2017), which was 4% less than the area planted in 2016. Corn acreage in the 2018 crop year is expected to remain about the same in most States because of anticipated higher returns for corn compared with other crops.

World Ammonia Production and Reserves:

	Plant production		Reserves[5]
	2016	2017[e]	
United States	10,200	10,500	Available atmospheric nitrogen and sources of natural gas for production of ammonia are considered adequate for all listed countries.
Algeria	1,130	1,200	
Australia	1,300	1,300	
Belarus	1,060	1,100	
Brazil	1,000	1,000	
Canada	4,140	4,100	
China	46,000	46,000	
Egypt	1,800	2,000	
France	2,600	2,600	
Germany	2,500	2,500	
India	10,800	11,000	
Indonesia	5,000	5,000	
Iran	2,640	2,700	
Malaysia	1,460	1,500	
Mexico	1,100	1,100	
Netherlands	2,300	2,300	
Oman	1,700	1,700	
Pakistan	2,600	2,600	
Poland	2,200	2,200	
Qatar	3,050	3,000	
Russia	12,500	13,000	
Saudi Arabia	4,100	4,100	
Trinidad and Tobago	4,910	4,900	
Ukraine	1,800	1,800	
Uzbekistan	1,200	1,200	
Venezuela	1,000	1,000	
Vietnam	1,100	1,100	
Other countries	13,100	13,100	
World total (rounded)	144,000	150,000	

World Resources: The availability of nitrogen from the atmosphere for fixed nitrogen production is unlimited. Mineralized occurrences of sodium and potassium nitrates, 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 noted)

Domestic Production and Use: The estimated f.o.b. mine value of marketable peat production in the conterminous United States was $13.2 million in 2017. Peat was harvested and processed by about 30 companies in 11 of the conterminous States. Peat production estimates for Alaska were unavailable for 2017. Florida and Minnesota were the leading producing States, in order of quantity harvested. Reed-sedge peat accounted for approximately 83% of the total volume produced, followed by sphagnum moss with 15%. About 93% of domestic peat was sold for horticultural use, including general soil improvement, nurseries, and potting soils. Other applications included earthworm culture medium, golf course construction, mixed fertilizers, mushroom culture, 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:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production	465	468	455	441	440
Commercial sales	453	479	460	443	460
Imports for consumption	915	994	1,150	1,130	1,100
Exports	41	29	28	30	30
Consumption, apparent[1]	1,380	1,390	1,620	1,590	1,500
Price, average value, f.o.b. mine, dollars per ton	25.37	24.97	28.39	31.97	30.00
Stocks, producer, yearend	174	222	179	125	150
Employment, mine and plant, number[e]	560	550	550	550	540
Net import reliance[2] as a percentage of apparent consumption	66	66	72	72	71

Recycling: None.

Import Sources (2013–16): Canada, 96%; and other, 4%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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. In the United States, the short-term outlook is for production to average about 440,000 tons per year and imported peat from Canada to account for more than 70% of domestic consumption.

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PEAT

The 2017 peat harvest season in Canada was influenced by favorable weather conditions resulting in expected peat harvest volumes for most of Canada's producing regions. Eastern Canada, the leading producing region, had a warm dry summer, with producers at or above average peat harvest volumes. The Prairie Provinces experienced a mixed peat harvest season as a result of a prolonged spring and cool wet summer months. The peat harvest in Quebec's South Shore was 10% below expectations. In Quebec's North Shore, which had favorable weather conditions throughout the harvest period, producers achieved or exceeded their expected peat harvest.

World Mine Production and Reserves: Countries that reported by volume only and had insufficient data for conversion to tons were combined and included with "Other countries." The reserves data for Latvia and Lithuania were revised based on information published by the Governments of these countries.

	Mine production		Reserves[3]
	2016	2017[e]	
United States	441	440	150,000
Belarus	1,530	1,500	2,600,000
Canada	1,120	1,200	720,000
Estonia	569	570	60,000
Finland	7,470	7,500	6,000,000
Germany	3,400	3,400	(4)
Ireland	4,290	4,300	(4)
Latvia	821	820	150,000
Lithuania	500	500	210,000
Poland	907	900	(4)
Russia	1,000	1,000	1,000,000
Sweden	2,110	2,100	(4)
Ukraine	570	570	(4)
Other countries[e]	1,400	1,400	1,400,000
World total (rounded)	26,100	26,200	12,000,000

World Resources: 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% annually 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 that country. Reserves data were estimated based on data from International Peat Society publications and the percentage of peat resources available for peat extraction. 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 noted)

Domestic Production and Use: In 2017, domestic sold and used processed crude perlite was estimated to be 455,000 tons with a value of $29.1 million. Crude ore production was from seven mines operated by six companies in five Western States. New Mexico continued to be the leading producing State. Processed crude perlite was expanded at 46 plants in 28 States. Domestic apparent consumption was 590,000 tons. The applications for expanded perlite were building construction products, 53%; horticultural aggregate, 15%; fillers, 15%; filter aid, 9%; and other, 8%. Other applications included specialty insulation and miscellaneous uses.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Mine production, crude ore	471	462	488	513	520
Sold or used, processed crude perlite	419	462	444	437	455
Imports for consumption[1]	156	144	143	188	160
Exports[1]	52	36	30	21	25
Consumption, apparent[2]	523	570	557	604	590
Price, average value, dollars per ton, f.o.b. mine	57	55	60	64	64
Employment, mine and mill, number	117	119	142	135	140
Net import reliance[3] as a percentage of apparent consumption	20	19	20	28	23

Recycling: Not available.

Import Sources (2013–16): Greece, 95%; Mexico, 2%; Turkey, 2%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Vermiculite, perlite and chlorites, unexpanded	2530.10.0000	Free.

Depletion Allowance: 10% (Domestic and foreign).

Government Stockpile: None.

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PERLITE

Events, Trends, and Issues: Perlite is a siliceous volcanic glass that expands up to 20 times its original volume when rapidly heated. Expanded perlite is used to provide moisture retention and aeration when added to soil. Construction applications for expanded perlite are numerous because it is lightweight, fire resistant, and an excellent insulator. Novel and small markets for perlite have increased during the past 10 years; environmental remediation has become an increasing market for perlite. During the final quarter of 2016 and throughout 2017, a new perlite deposit in Nevada was being actively explored and developed as a potential supplier of crude perlite ore for industrial and household applications.

Domestic perlite mining generally takes place in remote areas, and its environmental impact is not severe. The mineral fines, overburden, and reject ore produced during ore mining and processing are used to reclaim the mined-out areas, and, therefore, little waste remains. Airborne dust is captured by baghouses, and virtually no runoff contributes to water pollution.

Based on estimated world production for 2017, the world's leading producers were, in descending order of production, China, Greece, Turkey, and the United States, with about 35%, 30%, 20%, and 10%, respectively, of world production. Although China was the leading producer, most of its perlite production was thought to be consumed internally. Greece and Turkey remained the leading exporters of perlite.

World Processed Perlite Production and Reserves: Reserves for Greece were revised based on information from official Government sources.

	Production		Reserves[4]
	2016[e]	2017[e]	
United States	[5]513	[5]520	50,000
China	1,800	1,800	NA
Greece	1,490	1,550	120,000
Hungary	30	50	28,000
Iran	60	60	NA
Mexico	28	40	NA
Turkey	950	1,000	57,000
Other countries	115	120	NA
World total (rounded)	5,000	5,100	NA

World Resources: Insufficient information is available to make reliable estimates of resources in perlite-producing countries.

Substitutes: In construction applications, diatomite, expanded clay and shale, pumice, and slag can be substituted for perlite. For horticultural uses, vermiculite, coco coir, wood pulp, and pumice are alternative soil additives and are sometimes used in conjunction with perlite.

[e]Estimated. NA Not available.
[1]Exports and imports were estimated by the U.S. Geological Survey from U.S. Census Bureau combined data for vermiculite, perlite, and chlorites, unexpanded.
[2]Defined as sold or used processed perlite + imports – exports.
[3]Defined as imports − exports.
[4]See Appendix C for resource and reserve definitions and information concerning data sources.
[5]U.S. mine production of crude ore.

PHOSPHATE ROCK

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Phosphate rock ore was mined by five firms at 11 mines in four States and processed into an estimated 27.7 million tons of marketable product, valued at $2.1 billion, f.o.b. mine. Florida and North Carolina accounted for more than 75% of total domestic output; the remainder was produced in Idaho 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. Approximately 50% of the wet-process phosphoric acid produced was exported in the form of upgraded granular diammonium (DAP) and monoammonium phosphate (MAP) fertilizer, and merchant-grade phosphoric acid. The balance of the phosphate rock mined was for the manufacture of elemental phosphorus, which was used to produce phosphorus compounds for industrial applications.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production, marketable	31,200	25,300	27,400	27,100	27,700
Used by producers	28,800	26,700	26,200	26,700	26,700
Imports for consumption	3,170	2,380	1,960	1,590	2,100
Exports	—	—	—	—	—
Consumption, apparent[1]	31,900	29,100	28,100	28,200	28,800
Price, average value, dollars per ton, f.o.b. mine[2]	91.11	78.59	72.41	76.90	75.00
Stocks, producer, yearend	9,000	5,880	6,730	7,180	7,500
Employment, mine and beneficiation plant, number[e]	2,170	2,100	2,000	2,000	2,000
Net import reliance[3] as a percentage of apparent consumption	3	18	4	4	6

Recycling: None.

Import Sources (2013–16): Peru, 67%; Morocco, 32%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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. phosphate rock production and consumption was estimated to have increased in 2017. Hurricane Irma affected production of phosphate rock and fertilizers in Florida in September. Most mines and plants were closed temporarily because of power outages and flooding.

The leading United States phosphate rock producer agreed to purchase the phosphate and potash assets of the leading fertilizer producer in Brazil. The acquisition included five phosphate rock mines, one potash mine, and four phosphate fertilizer plants in Brazil and a potash mine project in Canada. The acquiring company also would get the other company's 40% stake in their joint venture mine in Peru, which would increase its stake to 75%.

A new phosphate rock mine, which was being developed in southeastern Idaho, was sold in 2017 to a multinational corporation that also has phosphate projects under development in Brazil, Guinea-Bissau, and Peru. A feasibility study for the project was completed in 2013, but lower phosphate rock prices and financial issues have delayed construction of the mine facility. The new owner has not stated when the mine would be completed. The multinational firm also purchased an existing phosphate rock mine and phosphate plant in Idaho. The phosphate facility was owned by the United States. subsidiary of a company in Canada that was merging with another fertilizer company in Canada. Sale of the facility was one of the requirements for the merger, which was expected to be completed by early 2018, pending approval by the U.S. Federal Trade Commission.

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PHOSPHATE ROCK

U.S. mine production annual capacity was expected to remain at 32.6 million tons for the next several years, because any new mines that are planned to open in Florida and Idaho would be replacements for existing mines. World mine production capacity, excluding China, was projected to increase to 168 million tons in 2021 from 147 million tons in 2017, according to industry analysts. The bulk of capacity increases will take place in Egypt, Jordan, Morocco, Senegal, and Turkey. Phosphate rock production in China was estimated by industry analysts to be around 85 million tons, which is considerably lower than the official data published by the Government of China.

In 2017, a new phosphate rock mine and fertilizer facility began operation in Saudi Arabia, which increased production capacity in the country to 10.5 million tons per year from 5.0 million tons per year. The leading United States integrated phosphate producer has a 25% stake in the associated DAP facility with two companies from Saudi Arabia.World consumption of P_2O_5, contained in fertilizers and other uses, was projected to increase to 48.8 million tons in 2021 from 45.7 million tons in 2017. Asia and South America would account for about 70% of the projected growth.

World Mine Production and Reserves: Reserves for Brazil, Egypt, Finland, Israel, Jordan, Peru, Saudi Arabia, and the United States were revised based on information from individual company reports. Data for China and Russia were revised based on information from Government sources.

	Mine production		Reserves[4]
	2016	2017[e]	
United States	27,100	27,700	1,000,000
Algeria	1,270	1,300	2,200,000
Australia	3,000	3,000	[5]1,100,000
Brazil	5,200	5,500	1,700,000
China[6]	135,000	140,000	3,300,000
Egypt	5,000	5,000	1,300,000
Finland	940	950	1,000,000
India	2,000	1,800	65,000
Israel	3,950	4,000	74,000
Jordan	7,990	8,200	1,300,000
Kazakhstan	1,500	1,600	260,000
Mexico	1,700	2,000	30,000
Morocco and Western Sahara	26,900	27,000	50,000,000
Peru	3,850	3,900	400,000
Russia	12,400	12,500	700,000
Saudi Arabia	4,200	4,500	1,400,000
Senegal	2,200	2,200	50,000
South Africa	1,700	1,800	1,500,000
Syria	—	100	1,800,000
Togo	850	1,000	30,000
Tunisia	3,660	3,700	100,000
Vietnam	2,800	3,000	30,000
Other countries	1,950	1,940	900,000
World total (rounded)	255,000	263,000	70,000,000

World Resources: 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, China, the Middle East, 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. — Zero.
[1]Defined as phosphate rock used by producers + imports – exports.
[2]Marketable phosphate rock, weighted value, all grades.
[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 reserves were about 290 million tons.
[6]Production data for large mines only, as reported by National Bureau of Statistics of China.

PLATINUM-GROUP METALS

(Platinum, palladium, rhodium, ruthenium, iridium, and osmium)
(Data in kilograms of platinum-group-metal content unless otherwise noted)

Domestic Production and Use: In 2017, one domestic company produced about 16,900 kilograms of platinum-group metals (PGMs) with an estimated value of about $480 million from its two mines in south-central Montana. Small quantities of primary PGMs also were recovered as byproducts of copper refining. The leading 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; in electronic applications, such as in computer hard disks, in multilayer ceramic capacitors, and in hybridized integrated circuits; in glass manufacturing; in jewelry; and in laboratory equipment. Platinum is used in the medical sector; platinum and palladium, along with gold-silver-copper-zinc alloys, are used as dental restorative materials. Platinum, palladium, and rhodium are used as investments as exchange-traded products and individual holding of physical bars and coins.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Mine production:[1]					
Platinum	3,720	3,660	3,670	3,890	3,900
Palladium	12,600	12,400	12,500	13,100	13,000
Imports for consumption[2]					
Platinum	38,600	45,800	42,700	42,300	48,000
Platinum waste and scrap	77,200	112,000	123,000	159,000	380,000
Palladium	83,100	92,900	85,300	80,400	80,000
Rhodium	11,100	11,100	10,600	10,700	12,000
Ruthenium	15,400	11,000	8,230	8,410	13,000
Iridium	1,740	1,960	1,010	1,300	1,600
Osmium	77	322	8	27	90
Exports[3]					
Platinum	11,100	14,800	14,400	14,000	16,000
Platinum waste and scrap	364,000	254,000	246,000	273,000	250,000
Palladium	25,900	22,100	23,000	17,500	38,000
Rhodium	1,220	433	759	794	650
Other PGMs	1,320	901	781	736	500
Price, dollars per troy ounce:[4]					
Platinum	1,489.57	1,387.89	1,056.09	989.52	960.00
Palladium	729.58	809.89	694.99	617.39	860.00
Rhodium	1,069.10	1,174.23	954.90	696.84	1,050.00
Ruthenium	75.63	65.13	47.63	42.00	61.00
Iridium	826.45	556.19	544.19	586.90	907.00
Employment, mine, number[1]	1,773	1,619	1,439	1,432	1,400
Net import reliance[5] as a percentage of apparent consumption:					
Platinum[6]	67	67	69	66	68
Palladium	60	65	53	53	45

Recycling: About 110,000 kilograms of platinum, palladium, and rhodium was recovered globally from new and old scrap in 2017, including about 55,000 kilograms recovered from automobile catalytic converters in the United States.

Import Sources (2013–16): Platinum:[2] South Africa, 40%; Germany, 15%; United Kingdom, 10%; Russia, 4%; and other, 31%. Palladium: South Africa, 30%; Russia, 25%; Italy, 14%; United Kingdom, 7%; and other, 24%.

Tariff: All unwrought and semimanufactured forms of PGMs are imported duty free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

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PLATINUM-GROUP METALS

Government Stockpile:

Stockpile Status—9–30–17[7]

Material	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Platinum	261	261	—
Iridium	15	15	—

Events, Trends, and Issues: The sole domestic PGM-mining company was sold to a South Africa-based mining company in May 2017. As of October, production was about the same as that in 2016. Progress continued on expansion development adjacent to one of its mines; development was ahead of schedule and first production was expected in the fourth quarter of 2017. The same mining company from South Africa also purchased platinum mines in South Africa, resulting in the company becoming the third-ranked platinum-producing company in the world.

Annual average prices of iridium, palladium, rhodium, and ruthenium increased by 55%, 39%, 51%, and 45%, respectively, compared with those of 2016. The average annual price of platinum was 3% lower than that of 2017 owing to a decrease in demand for diesel automobiles, in which platinum is used in catalytic converters. The palladium price increase was owing to increased demand for gasoline-powered automobiles, in which palladium is used in catalytic converters. The price increases for iridium and ruthenium were a result of increased industrial demand. In September, the price of palladium was briefly higher than that of platinum, which has not been the case since 2001.

Introduction of more stringent emission standards for automobiles in some countries is expected to result in increased demand for palladium, platinum, and rhodium for use in catalytic converters. Increased automobile production in developing countries indicates expected increased demand for PGMs beyond 2017.

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

	Mine production				PGMs
	Platinum		Palladium		Reserves[8]
	2016	2017[e]	2016	2017[e]	
United States	3,890	3,900	13,100	13,000	900,000
Canada	12,600	12,000	21,000	19,000	310,000
Russia	23,000	21,000	79,400	81,000	3,900,000
South Africa	133,000	140,000	76,300	78,000	63,000,000
Zimbabwe	14,900	15,000	12,000	12,000	1,200,000
Other countries	3,300	4,000	8,200	8,400	NA
World total (rounded)	191,000	200,000	210,000	210,000	69,000,000

World Resources: World resources of PGMs are estimated to total more than 100 million kilograms. The largest reserves are in the Bushveld Complex in South Africa.

Substitutes: Palladium has been substituted 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]Estimates from published sources.
[2]Includes data for the following Harmonized Tariff Schedule 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, 7112.92.0000, and 7118.90.0020.
[3]Includes data for the following Schedule B numbers: 7110.11.0000, 7110.19.0000, 7110.21.0000, 7110.29.0000, 7110.31.0000, 7110.41.0000, 7110.49.0000, and 7112.92.0000.
[4]Engelhard Corp. unfabricated metal.
[5]Defined as imports – exports + adjustments for industry stock changes.
[6]Excludes imports and exports of waste and scrap.
[7]See Appendix B for definitions.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.

POTASH

(Data in thousand metric tons of K_2O equivalent unless otherwise noted)

Domestic Production and Use: In 2017, the estimated sales value of marketable potash, f.o.b. mine, was $400 million, which was 25% less than that in 2016. Potash denotes a variety of mined and manufactured salts, which contain the element potassium in water-soluble form. In agriculture, the term potash refers to potassic fertilizers, which are potassium chloride (KCl), potassium sulfate or sulfate of potash (SOP), and potassium magnesium sulfate (SOPM) or langbeinite. Muriate of potash (MOP) is an agriculturally acceptable mix of KCl (95% pure or greater) and sodium chloride for fertilizer use. Most U.S.production was from southeastern New Mexico, where two companies operated three 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, or combinations of these processes, and provided more than 75% of total U.S. producer sales. 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 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 SOP and other byproducts.

The fertilizer industry used about 85% of U.S. potash sales, and the remainder was used for chemical and industrial applications. About 75% of the potash produced was SOPM and SOP, which are required by certain crops and soils. MOP accounted for the remaining 25% of production and was used for agricultural and chemical applications.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production, marketable[1]	960	850	740	500	480
Sales by producers, marketable[1]	880	930	620	600	510
Imports for consumption	4,650	4,970	5,000	4,550	5,700
Exports	255	100	106	99	100
Consumption, apparent[1, 2]	5,300	5,800	5,500	5,000	6,100
Value, dollars per ton of K_2O, average, all products, f.o.b. mine[3]	715	735	880	680	790
Employment, number, mine and mill	1,600	1,400	1,300	1,150	900
Net import reliance[4] as a percentage of apparent consumption	82	85	87	90	92

Recycling: None.

Import Sources (2013–16): Canada, 83%; Russia, 8%; Israel, 3%; Chile, 2%; and other, 4%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Potassium nitrate	2834.21.0000	Free.
Potassium chloride	3104.20.0000	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 production of potash was slightly lower than that in 2016, owing to the indefinite closure of an underground mine in New Mexico. Production data are rounded to avoid disclosing company proprietary data. Imports of MOP from Canada increased in 2017 to compensate for reductions in MOP production in New Mexico. U.S consumption was estimated to have increased because of stronger demand for potash fertilizers. The only U.S. producer of SOP planned to complete a capacity expansion of its solar evaporation facility on the Great Salt Lake in Utah by early 2018. This will increase its annual production capacity to 500,000 tons of SOP (255,000 tons of K_2O).

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POTASH

A company from Canada continued to develop a potash mine and processing facility in southeastern New Mexico. The firm initially had planned to produce SOP from polyhalite (a potassium-calcium-magnesium sulfate mineral), but revised its plans to market polyhalite as a specialty crop nutrient to avoid incurring the cost of constructing a SOP production facility. A new feasibility study was expected to be completed by early 2018 and the company expected to start production by 2020.

In Canada, a potash producer based in Germany started production at a new solution mine in Saskatchewan. The initial annual production capacity of the mine was 2 million tons of MOP (1.2 million tons of K_2O). The company planned to increase capacity incrementally to 2.9 million tons of MOP by 2022. A proposed merger between two of the three largest Canadian potash producers received approval from authorities in Canada, Brazil, India, and Russia in 2017. Approval by the U.S. Federal Trade Commission and regulators in China was expected by the end of 2017. If approved, the new company would be the world's largest potash producer with 33% of world capacity.

In 2017, new potash mines started production in Canada, Russia, and Turkmenistan. Between 2018 and 2021, other new mines globally were planned to start production in Belarus, China, Russia, and Spain, and expansions to existing facilities were ongoing in Belarus, China, and Russia. These new projects would increase world production capacity to 65.5 million tons of K_2O in 2021 from 59.9 million tons of K_2O in 2017. Other new potash mine projects in Australia, Canada, China, Eritrea, Ethiopia, Laos, Peru, and the United Kingdom have been delayed until after 2021 owing to financing difficulties and low potash prices. Canada, Russia, and Belarus will remain the leading world producers and suppliers, by order of magnitude. World potash demand for all uses was projected to increase to 45.6 million tons in 2021 from 42.0 million tons in 2017, with the largest consumption in Asia and South America.

World Mine Production and Reserves: Reserves for Brazil, Russia, Spain, the United Kingdom, and the United States were revised with information contained in individual company reports.

	Mine production		Reserves[5]	
	2016	2017[e]	Recoverable ore	K_2O equivalent
United States[1]	500	480	1,000,000	210,000
Belarus	6,180	6,400	3,300,000	750,000
Brazil	301	300	310,000	24,000
Canada	10,800	12,000	4,200,000	1,000,000
Chile	1,200	1,200	NA	150,000
China	6,200	6,200	NA	360,000
Germany	2,800	2,900	NA	150,000
Israel	2,050	2,200	NA	[6]270,000
Jordan	1,200	1,300	NA	[6]270,000
Russia	6,480	7,200	3,000,000	500,000
Spain	670	680	NA	44,000
United Kingdom	450	450	NA	40,000
Other countries	480	500	250,000	90,000
World total (rounded)	39,300	42,000	NA	3,900,000

World Resources: 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 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 sources that can be profitably transported only short distances to crop fields.

[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, SOPM, and some parent salts. 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]Total reserves in the Dead Sea are divided equally between Israel and Jordan for inclusion in this tabulation.

PUMICE AND PUMICITE

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: In 2017, 10 operations in five States produced pumice and pumicite. Estimated production[1] was 380,000 tons with an estimated processed value of about $15 million, f.o.b. plant. Pumice and pumicite were mined in Oregon, California, Idaho, New Mexico, and Kansas, in descending order of production. About 50% of mined pumice was used in the production of construction building block and 20% was used for horticultural purposes. The remainder was consumed in abrasives, concrete admixtures and aggregates, and other uses, including absorbent, filtration, laundry stone washing, and road use.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, mine[1]	269	269	310	374	380
Imports for consumption	73	60	64	170	150
Exports[e]	13	14	11	9	11
Consumption, apparent[2]	329	315	363	535	520
Price, average value, dollars per ton, f.o.b. mine or mill	35	39	33	38	40
Employment, mine and mill, number	140	140	140	140	140
Net import reliance[3] as a percentage of apparent consumption	18	15	15	30	27

Recycling: Little to no known recycling.

Import Sources (2013–16): Greece, 94%; Iceland, 4%; and Mexico, 2%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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.

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PUMICE AND PUMICITE

Events, Trends, and Issues: The amount of domestically produced pumice and pumicite sold or used in 2017 was slightly more than that in 2016. Imports decreased and exports increased compared with those of 2016. Almost all imported pumice originated from Greece in 2017, and primarily supplied markets in the eastern and Gulf Coast regions of the United States. Turkey and Italy are the leading global producers of pumice and pumicite.

Although pumice and pumicite are plentiful in the Western United States, legal challenges and public land designations could limit access to known deposits. Pumice and pumicite production is sensitive to mining and transportation costs. Although unlikely in the short term, an increase in fuel prices would likely lead to increases in production costs; imports and competing materials could become attractive substitutes for domestic products.

All known domestic pumice and pumicite mining in 2017 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 are thought to be restricted to relatively small geographic areas.

World Mine Production and Reserves:

	Mine production		Reserves[4]
	2016	2017[e]	
United States[1]	374	380	Large in the United States. Quantitative estimates of reserves for most countries are not available.
Algeria[5]	350	350	
Cameroon[5]	360	360	
Chile[5]	800	800	
Ecuador[5]	180	180	
Ethiopia	600	600	
France[5]	280	280	
Greece[5]	870	870	
Guadeloupe	200	200	
Italy[5]	4,000	4,000	
Saudi Arabia[5]	480	480	
Spain	200	200	
Syria[5]	260	260	
Turkey	6,700	6,700	
Uganda	740	740	
Other countries[5]	710	710	
World total (rounded)	17,100	17,000	

World Resources: The identified U.S. resources of pumice and pumicite are concentrated in the Western States and estimated to be more than 25 million tons. 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]Includes pozzolan and (or) volcanic tuff.

QUARTZ CRYSTAL (INDUSTRIAL)

(Data in kilograms unless otherwise noted)

Domestic Production and Use: Industrial cultured quartz crystal is electronic-grade quartz crystal that is manufactured, not mined. In the past, cultured quartz was primarily produced using lascas[1] as raw quartz feed material. Lascas mining and processing in Arkansas ended in 1997. Cultured quartz crystal is produced by two companies in the United States, but production statistics were not available. One of these companies uses cultured quartz crystal that has been rejected during the manufacturing process, owing to crystallographic imperfections, as feed material. The companies may 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 filters, frequency controls, 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: The U.S. Census Bureau, which is the primary Government source of U.S. trade data, does not provide import or export statistics specific to lascas or electronic and optical-grade quartz crystal, but does report specifically on mounted piezoelectric crystals. The price of as-grown cultured quartz was estimated to be $280 per kilogram in 2017, unchanged from 2016. Lumbered quartz, which is as-grown cultured quartz that has been processed by sawing and grinding, was estimated to be $890 per kilogram in 2017, but the price can range from $20 per kilogram to more than $1,500 per kilogram, depending on the application. Other salient statistics were not available.

Recycling: An unspecified amount of rejected cultured quartz crystal was used as feed material for the production of cultured quartz crystal.

Import Sources (2013–16): Although no definitive data exist listing import sources for cultured quartz crystal, imported material is thought to be mostly from China, Japan, Romania, and the United Kingdom.

Tariff:

Item	Number	Normal Trade Relations 12–31–17
Quartz (including lascas)	2506.10.0050	Free.
Piezoelectric quartz, unmounted	7104.10.0000	3% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: As of September 30, 2017, the National Defense Stockpile (NDS) contained 7,148 kilograms of natural quartz crystal. The stockpile has 11 weight classes for natural quartz crystal that range from 0.2 kilogram to more than 10 kilograms. The stockpiled crystals, however, are primarily in the larger weight classes. The larger pieces are suitable as seed crystals, which are very thin crystals cut to exact dimensions, to produce cultured quartz crystal. In addition, many of the stockpiled crystals could be of interest to the specimen and gemstone industry. Little, if any, of the stockpiled material is likely to be used in the same applications as cultured quartz crystal. No natural quartz crystal was sold from the NDS in 2017. Previously, only individual crystals in the stockpile that weighed 10 kilograms or more and that could be used as seed material were sold.

Stockpile Status—9–30–17[2]

Material	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Quartz crystal	7,148	—	—

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QUARTZ CRYSTAL (INDUSTRIAL)

Events, Trends, and Issues: Demand for quartz crystal for frequency-control oscillators and frequency filters in a variety of electronic devices is expected to remain stable. However, silicon has replaced quartz crystal in two very important markets—cellular telephones and other mobile devices and automotive stability control applications. Growth of the consumer electronics market, for products such as personal computers, electronic games, and tablet computers, is likely to continue to sustain global production of quartz crystal.

World Mine Production and Reserves:[3] This information is unavailable, but the global reserves for lascas are thought to be large.

World Resources: Limited resources of natural quartz crystal suitable for direct electronic or optical use are available throughout the world. World dependence on these 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 could mean a decreased dependence on lascas for growing cultured quartz.

Substitutes: 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. 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.

— Zero.

[1]Lascas is a nonelectronic-grade quartz used as a feedstock for growing cultured quartz crystal and for production of fused quartz.

[2]See Appendix B for definitions.

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

RARE EARTHS[1]

[Data in metric tons of rare-earth oxide (REO) equivalent content unless otherwise noted]

Domestic Production and Use: Rare earths were not mined domestically in 2017. Bastnaesite, a rare-earth fluorocarbonate mineral, was previously mined as a primary product at Mountain Pass, CA, which was put on care-and-maintenance status in the fourth quarter of 2015. The estimated value of rare-earth compounds and metals imported by the United States in 2017 was $150 million, a significant increase from $118 million imported in 2016. The estimated distribution of rare earths by end use was as follows: catalysts, 55%; ceramics and glass, 15%; metallurgical applications and alloys, 10%; polishing, 5%; and other, 15%.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, bastnäsite concentrates	5,500	5,400	5,900	—	—
Imports:[2]					
Compounds:					
Cerium compounds	1,110	2,990	1,440	1,830	2,700
Other rare-earth compounds	7,330	9,260	7,720	9,650	9,300
Metals:					
Ferrocerium, alloys	313	371	356	269	290
Rare-earth metals, scandium, and yttrium	393	348	385	404	400
Exports:[2]					
Compounds:					
Cerium compounds	734	608	440	309	220
Other rare-earth compounds	5,570	3,780	4,540	281	420
Metals:					
Ferrocerium, alloys	1,420	1,640	1,220	943	1,300
Rare-earth metals, scandium, and yttrium	1,050	140	60	103	140
Consumption, apparent[3]	5,870	12,200	9,550	10,500	11,000
Price, dollars per kilogram, yearend[4]					
Cerium oxide, 99.5% minimum	5–6	4–5	2	2	3
Dysprosium oxide, 99.5% minimum	440–490	320–360	215–240	185–193	180–190
Europium oxide, 99.99% minimum	950–1,000	680–730	90–110	62–70	75–80
Lanthanum oxide, 99.5% minimum	6	5	2	2	3
Mischmetal, 65% cerium, 35% lanthanum	9–10	9–10	5–6	5–6	6
Neodymium oxide, 99.5% minimum	65–70	56–60	39–42	38–40	56–59
Terbium oxide, 99.99% minimum	800–850	590–640	410–470	410–425	470–480
Employment, mine and mill, annual average	380	391	351	—	—
Net import reliance[5] as a percentage of apparent consumption	6	56	38	100	100

Recycling: Limited quantities, from batteries, permanent magnets, and fluorescent lamps.

Import Sources (2013–16): Rare-earth compounds and metals: China, 78%; Estonia, 6%; France, 4%; Japan, 4%; and other, 8%. Imports of compounds and metals from Estonia, France, and Japan were derived from mineral concentrates produced in China and elsewhere.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Rare-earth metals, scandium, and yttrium, whether or not intermixed or interalloyed	2805.30.0000	5.0% ad val.
Cerium compounds:		
Oxides	2846.10.0010	5.5% ad val.
Other	2846.10.0050	5.5% ad val.
Other rare-earth compounds:		
Lanthanum oxides	2846.90.2005	Free.
Other oxides	2846.90.2040	Free.
Lanthanum carbonates	2846.90.8070	3.7% ad val.
Other carbonates	2846.90.8075	3.7% ad val.
Other rare-earth compounds	2846.90.8090	3.7% ad val.
Ferrocerium and other pyrophoric alloys	3606.90.3000	5.9% ad val.

Depletion Allowance: Monazite, 22% on thorium content and 14% on rare-earth content (Domestic), 14% (Foreign); bastnäsite and xenotime, 14% (Domestic and foreign).

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RARE EARTHS

Government Stockpile: The Defense Logistics Agency's annual materials plan for fiscal year 2018 included a potential acquisition of 0.5 tons of dysprosium, 18 tons of europium, 416 tons of unspecified rare earths, and 10 tons of yttrium oxide.

Stockpile Status—9–30–17[6]

Material	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Dysprosium	0.1	—	—
Europium	—	—	—
Ferrodysprosium, gross weight	0.5	—	—
Yttrium oxide	24.5	—	—

Events, Trends, and Issues:. In Nebraska, one company commissioned an operation that produced separated rare-earth oxides from an initial production feedstock material from recycled fluorescent light bulbs. The company planned to ramp up production to 18 tons per month using a proprietary technology. In China, the rare-earth mining production quota for 2017 was set at 105,000 tons, unchanged from that in 2016. The rare-earths industry in China continued its consolidation into six major industrial entities. At midyear, the consolidation and efforts to stem illegal production activity were reported to have bolstered prices of some rare-earth materials; however, by yearend, producers in China were suspending production and lowering prices owing to low demand. Through September 2017, China had exported 39,800 tons of rare-earth materials, a 10% increase compared with exports for the same period in 2016. Global exports of rare-earth compounds from Malaysia, a leading supplier of material sourced outside of China, increased to 15,100 tons through August, a 57% increase compared with year-to-date exports in 2016. Mineral concentrates from Australia are used to produce compounds in Malaysia.

World Mine Production and Reserves:

	Mine production[e]		Reserves[7]
	2016	2017	
United States	—	—	1,400,000
Australia	15,000	20,000	[8]3,400,000
Brazil	2,200	2,000	22,000,000
Canada	—	—	830,000
China	[9]105,000	[9]105,000	44,000,000
Greenland	—	—	1,500,000
India	1,500	1,500	6,900,000
Malawi	—	—	140,000
Malaysia	300	300	30,000
Russia	2,800	3,000	[10]18,000,000
South Africa	—	—	860,000
Thailand	1,600	1,600	NA
Vietnam	220	100	22,000,000
World total (rounded)	129,000	130,000	120,000,000

World Resources: Rare earths are relatively abundant in the Earth's crust, but minable concentrations are less common than for most other ores. Resources are primarily in four geologic environments: carbonatites, alkaline igneous systems, ion-adsorption clay deposits, and monazite-xenotime-bearing placer deposits. Carbonatites and placer deposits are the leading sources of production of light rare-earth elements. Ion-adsorption clays are the leading source of production of heavy rare-earth elements.

Substitutes: Substitutes are available for many applications but generally are less effective.

[e]Estimated. NA Not available. — Zero.
[1]Data include lanthanides and yttrium but exclude most scandium. See also Scandium and Yttrium.
[2]REO equivalent or content of various materials were estimated. Source: U.S. Census Bureau.
[3]Defined as production + imports – exports.
[4]Price range from Argus Media group – Argus Metals International.
[5]Defined as imports – exports.
[6]See Appendix B for definitions.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]For Australia, Joint Ore Reserves Committee-compliant reserves were about 2.1 million tons.
[9]Production quota does not include undocumented production.
[10]Reserves and resources in Russia's categories A, B, and C1 were about 27 million tons.

RHENIUM

(Data in kilograms of rhenium content unless otherwise noted)

Domestic Production and Use: During 2017, ores containing 8,500 kilograms of rhenium were mined at six operations (four in Arizona, and one each in Montana and Utah). Rhenium compounds are included in molybdenum concentrates derived from porphyry copper deposits, and rhenium is recovered as a byproduct from roasting such molybdenum concentrates. Rhenium-containing products included ammonium perrhenate (APR), metal powder, and perrhenic acid. 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 for the production of high-octane hydrocarbons, which are used in the production of lead-free gasoline. Rhenium improves the high-temperature (1,000 °C) 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. The value of rhenium consumed in 2017 was about $80 million as measured by the value of imports of rhenium metal and APR.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production[1]	7,110	8,510	7,900	8,440	8,500
Imports for consumption[2]	27,600	25,000	31,800	31,900	34,100
Exports	NA	NA	NA	NA	NA
Consumption, apparent[3]	34,700	33,500	39,700	40,300	42,600
Price, average value, dollars per kilogram, gross weight:[4]					
Metal pellets, 99.99% pure	3,160	2,980	2,670	2,030	1,530
Ammonium perrhenate	3,400	3,080	2,820	2,510	1,550
Employment, number	Small	Small	Small	Small	Small
Net import reliance[5] as a percentage of apparent consumption	80	75	80	79	80

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 were also processed to generate engine revert—a high-quality, lower cost superalloy meltstock—by an increasing number of companies, mainly in the United States, Canada, Estonia, Germany, and Russia. Rhenium-containing catalysts were also recycled.

Import Sources (2013–16): Ammonium perrhenate: Kazakhstan, 44%; Republic of Korea, 22%; Canada, 11%; Germany, 7%; and other, 16%. Rhenium metal powder: Chile, 86%; Belgium, 4%; Germany, 4%; Poland, 3%; and other, 3%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Salts of peroxometallic acids, other, ammonium perrhenate	2841.90.2000	3.1% ad val.
Rhenium (and other metals), waste and scrap	8112.92.0600	Free.
Rhenium, unwrought and powders	8112.92.5000	3% ad val.
Rhenium (and other metals), wrought	8112.99.9000	4% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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RHENIUM

Events, Trends, and Issues: During 2017, the United States continued to rely on imports for much of its supply of rhenium. Canada, Chile, Germany, Kazakhstan, and the Republic of Korea supplied most of the imported rhenium. Rhenium imports for consumption increased by 7% from those of 2016. Primary rhenium production in the United States remained essentially unchanged compared with that in 2016. A new molybdenum processing plant in Chile shipped its first molybdenum concentrate in the fourth quarter of 2016. The plant had the capacity to produce 16,500 tons per year of molybdenum trioxide and 8,000 kilograms of rhenium per year. Germany and the United States continued to be the leading secondary rhenium producers. Secondary rhenium production also took place in Canada, Estonia, France, Japan, Poland, and Russia. Secondary production estimates were not available. For the sixth year in a row, rhenium metal and catalytic-grade APR prices declined. In 2017, catalytic-grade APR prices averaged $1,550 per kilogram, 38% less than that in 2016. Rhenium metal pellet prices averaged $1,530 per kilogram in 2017, 25% less than that in 2016.

Consumption of catalyst-grade APR by the petroleum industry was expected to remain at high levels. Demand for rhenium in the aerospace industry, although more unpredictable, was expected to continue to increase. The major aerospace companies, however, were expected to continue testing superalloys that contain one-half the quantity of rhenium used in engine blades as currently designed, as well as testing rhenium-free alloys for other engine components. New technology continued to be developed to allow recycling of nickel-base superalloy scrap more efficiently. The processing of scrapped engine parts to generate engine revert increased worldwide and this increase in engine revert supply was expected to continue to have a significant impact on the rhenium market.

World Mine Production and Reserves:

	Mine production[6]		Reserves[7]
	2016	2017[e]	
United States	8,440	8,500	390,000
Armenia	350	350	95,000
Canada	—	—	32,000
Chile[8]	27,000	27,000	1,300,000
China	3,000	3,000	NA
Kazakhstan	1,000	1,000	190,000
Peru	—	—	45,000
Poland	9,000	9,000	NA
Russia	NA	NA	310,000
Uzbekistan	1,000	1,000	NA
Other countries	1,800	1,800	91,000
World total (rounded)	51,600	52,000	2,500,000

World Resources: Most rhenium occurs with molybdenum in porphyry copper deposits. Identified U.S. resources are estimated to be about 5 million kilograms, and the identified resources of the rest of the world are approximately 6 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 being evaluated continually. Iridium and tin have achieved commercial success in one such application. 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 is not included.

[2]Does not include wrought forms or waste and scrap. The rhenium content of ammonium perrhenate is 69.42%.

[3]Defined as production + imports – exports.

[4]Average price per kilogram of rhenium in pellets or catalytic-grade ammonium perrhenate, from Argus Media group–Argus Metals International.

[5]Defined as imports – exports.

[6]Estimated amount of rhenium recovered in association with copper and molybdenum production. Secondary rhenium production not included.

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

[8]Estimated rhenium recovered from roaster residues from Belgium, Chile, and Mexico.

RUBIDIUM

(Data in metric tons of rubidium oxide unless otherwise noted)

Domestic Production and Use: Rubidium is not actively mined in the United States; however, occurrences 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; it is produced in small quantities as a byproduct of cesium, lithium, and strontium mining. 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. The source of the majority of U.S. pollucite imports is the largest known deposit in North America at Bernic Lake, Manitoba, Canada; however, mining ceased at that operation at the end of 2015.

Applications for rubidium and its compounds include biomedical research, electronics, specialty glass, and pyrotechnics. Specialty glasses are the leading market for rubidium; rubidium carbonate is used to reduce electrical conductivity, which improves stability and durability in fiber optic telecommunications networks. Biomedical applications include rubidium salts used in antishock agents and the treatment of epilepsy and thyroid disorder; rubidium-82, a radioactive isotope used as a blood-flow tracer in positron emission tomographic imaging; and rubidium chloride, used as an antidepressant. 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 research uses ultracold rubidium atoms in a variety of applications. Quantum computers, which have the ability to perform more complex computational tasks than traditional computers by calculating in two quantum states simultaneously, were expected to be in prototype phase by 2025.

Rubidium's photoemissive properties make it ideal for electrical-signal generators in motion-sensor devices, night-vision devices, photoelectric cells (solar panels), and photomultiplier tubes. Rubidium is used as an atomic resonance-frequency-reference oscillator for telecommunications network synchronization, playing a vital role in global positioning systems. Rubidium-rich feldspars are used in ceramic applications for spark plugs and electrical insulators because of their high dielectric constant. Rubidium hydroxide is 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 48 weighted atomic clocks, including 4 USNO rubidium fountain clocks.

Salient Statistics—United States: U.S. salient statistics, such as consumption, exports, and imports, are not available. Some concentrate, which was primarily from Canada, was exported to the United States for further processing. Industry information during the past decade suggests a domestic consumption rate of approximately 2,000 kilograms per year.

In 2017, one company offered 1-gram ampoules of 99.75%-grade rubidium (metals basis) for $82.70, a slight decrease from $83.13 in 2016, and 100-gram ampoules of the same material for $1,516.00, a 29% increase from $1,177.60 in 2016. The price for 10-gram ampoules of 99.8% rubidium formate hydrate (metals basis) was $55.10, a 23% increase from $44.96 in 2016. In 2017, the prices for 10 grams of 99.8% (metals basis) rubidium acetate, rubidium bromide, rubidium carbonate, rubidium chloride, and rubidium nitrate were $47.90, $63.20, $58.10, $57.00, and $45.00, respectively. The price for a rubidium-plasma standard solution (10,000 µg/ml) was $55.40 for 50 milliliters, a slight decrease from 2016, and $82.50 for 100 milliliters, a 22% increase from $67.49 in 2016.

Recycling: None.

Import Sources (2013–16): The United States is 100% import reliant on byproduct rubidium concentrate imports, most of which were thought to be imported from Canada.

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RUBIDIUM

Tariff:

Item	Number	Normal Trade Relations 12–31–17
Alkali metals, other	2805.19.9000	5.5% ad val.
Chlorides, other	2827.39.9000	3.7% ad val.
Bromides, other	2827.59.5100	3.6% ad val.
Nitrates, other	2834.29.5100	3.5% ad val.
Carbonates, other	2836.99.5000	3.7% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic rubidium occurrences will remain uneconomic 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 2017, projects that were primarily aimed at developing lithium resources were at various stages of development, including the Soris Lithium Project in Namibia and the Jubilee Lake Lithium Prospect in Canada. The projects focused on pegmatites containing pollucite and spodumene, which primarily contain lithium, tantalum, or both, but may also contain minor quantities of cesium and rubidium.

World Mine Production and Reserves: Production of pollucite ceased at the Bernic Lake operation in Manitoba, Canada at the end of 2015; however, it was expected that rubidium concentrate would continue to be produced as a byproduct of processing from pollucite stocks. 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, which are exceptionally coarse-grained plutonic rocks that formed late in the crystallization of a silicic magma. Mineral resources exist globally, but extraction and concentration are cost prohibitive. Production is known to take place periodically in Namibia and Zimbabwe, but production data are not available. Rubidium is thought to be mined in China, but information regarding reserves and production is unavailable. Resources previously classified as reserves at the Manitoba, Canada, operation were no longer considered economically recoverable following a mine collapse in 2015.

	Reserves[1]
Namibia	50,000
Zimbabwe	30,000
Other countries	10,000
World total	90,000

World Resources: In addition to several significant rubidium-bearing zoned pegmatites in Canada, similar pegmatite occurrences have been identified in Afghanistan, China, Denmark, Germany, Japan, Kazakhstan, Namibia, Peru, Russia, the United Kingdom, the United States, and Zambia. Minor amounts of rubidium are reported in brines in northern Chile and China and in evaporites in France, Germany, and the United States (New Mexico and Utah).

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 noted)

Domestic Production and Use: Domestic production of salt was estimated to have increased slightly in 2017 to 43 million tons. The total value of salt sold or used was estimated to be about $1.9 billion. Twenty-eight companies operated 63 plants in 16 States. The top producing States, in alphabetical order, were Kansas, Louisiana, Michigan, New York, Ohio, Texas, and Utah. These seven States produced about 95% of the salt in the United States in 2017. The estimated percentage of salt sold or used was, by type, rock salt, 41%; salt in brine, 41%; solar salt, 9%; and vacuum pan salt, 9%.

Highway deicing accounted for about 44% of total salt consumed. The chemical industry accounted for about 37% of total salt sales, with salt in brine accounting for 87% 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, in declining order of use, distributors, 8%; agricultural and food processing, 3% each; other uses combined with exports and general industrial, 2% each; and primary water treatment, 1%.

Salient Statistics—United States:[1]	2013	2014	2015	2016	2017[e]
Production	39,900	45,300	45,100	[e]42,000	43,000
Sold or used by producers	43,100	46,000	42,800	[e]38,000	39,000
Imports for consumption	11,900	20,200	21,600	12,100	13,000
Exports	525	935	841	716	1,100
Consumption:					
Apparent[2]	54,500	65,300	63,600	[e]49,400	50,000
Reported	47,600	55,600	52,300	[e]42,000	43,000
Price, average value of bulk, pellets and packaged salt, dollars per ton, f.o.b. mine and plant:					
Vacuum and open pan salt	172.09	180.61	188.87	[e]190.00	190.00
Solar salt	78.04	75.35	82.45	[e]87.00	90.00
Rock salt	47.22	48.11	56.32	[e]50.00	45.00
Salt in brine	8.49	9.08	10.27	[e]10.50	9.40
Employment, mine and plant, number[e]	4,100	4,200	4,200	4,100	4,100
Net import reliance[3] as a percentage of apparent consumption	22	29	33	23	23

Recycling: None.

Import Sources (2013–16): Chile, 38%; Canada, 31%; Mexico, 11%; The Bahamas, 4%; and other, 16%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Salt (sodium chloride)	2501.00.0000	Free.

Depletion Allowance: 10% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: The winter was warmer than average in 2016–17 for the second straight year. The amount of frozen precipitation and the number of winter weather events was below average in many parts of the United States, requiring less salt for highway deicing. Rock salt production and imports in 2017 increased only slightly from the levels in 2016 because demand from many local and State transportation departments was relatively stable. The majority of local and State governments in cold regions reportedly had rebuilt their stockpiles and had large supplies of rock salt available for the winter of 2016–17. As winter ended, many consumers of rock salt had substantial stockpiles of salt remaining as they considered salt purchases for the next winter season. Owing to the flat demand for deicing salt, many buyers were experiencing decreases in rock salt unit prices.

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SALT

For the winter of 2017–18, the National Oceanic and Atmospheric Administration predicted another La Niña weather pattern of a cooler and snowier winter for the traditional snowbelt in the northern tier of the United States, with average or above-average winter precipitation and average to cooler temperatures. The southern part of the United States was expected to be warmer and dryer than average. This was likely to have little impact on consumption of salt for deicing compared to the 2016–17 winter season because of similar weather conditions. It was anticipated that the salt industry would be able to provide adequate salt supplies from domestic and foreign sources for emergency use in the event of harsher than anticipated winter weather.

Demand for salt brine used in the chloralkali industry was expected to increase as demand for caustic soda increased globally, especially in Asia. Exports from India increased to supply the growing demand for caustic soda in China.

World Production and Reserves:

	Production[e]		Reserves[4]
	2016	2017	
United States[1]	42,000	43,000	Large. Economic and subeconomic deposits of salt are substantial in principal salt-producing countries. The oceans contain a virtually inexhaustible supply of salt.
Australia	11,000	11,000	
Brazil	7,600	7,500	
Canada	14,000	13,000	
Chile	12,000	12,000	
China	67,000	68,000	
France	6,000	6,000	
Germany	12,000	13,000	
India	25,000	26,000	
Mexico	8,800	9,000	
Poland	3,500	3,500	
Spain	4,300	4,300	
Turkey	11,000	11,000	
United Kingdom	5,000	5,000	
Other countries	45,000	45,000	
World total (rounded)	270,000	280,000	

World Resources: 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 noted)

Domestic Production and Use: In 2017, 890 million tons of construction sand and gravel valued at more than $7.7 billion was produced by an estimated 3,600 companies operating 9,400 pits and 360 sales/distribution yards in 50 States. Leading producing States were, in order of decreasing tonnage, California, Texas, Minnesota, Michigan, Arizona, Colorado, Washington, Ohio, Wisconsin, and New York, which together accounted for about 52% of total output. It is estimated that about 44% of construction sand and gravel was used as concrete aggregates; 25% for road base and coverings and road stabilization; 13% as asphaltic concrete aggregates and other bituminous mixtures; 12% as construction fill; 1% each for concrete products, such as blocks, bricks, and pipes; plaster and gunite sands; and snow and ice control; and the remaining 3% for filtration, golf courses, railroad ballast, roofing granules, 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 2017 was 673 million tons, a slight decrease compared with that of the same period of 2016. Third quarter shipments for consumption were virtually unchanged compared with those of the same period of 2016. Additional production information by quarter for each State, geographic region, and the United States is published by the U.S. Geological Survey in its quarterly Mineral Industry Surveys for Crushed Stone and Sand and Gravel.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production	824	831	885	892	890
Imports for consumption	4	4	4	3	8
Exports	([2])	([2])	([2])	([2])	([2])
Consumption, apparent[3]	830	830	890	900	900
Price, average value, dollars per metric ton	7.76	8.03	8.22	8.57	8.70
Employment, mine and mill, number[4]	36,400	34,600	34,800	35,300	34,100
Net import reliance[5] as a percentage of apparent consumption	([2])	([2])	([2])	([2])	1

Import Sources (2013–16): Canada, 93%; Mexico, 4%; and other, 3%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–17**
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: Construction sand and gravel production was about 890 million tons in 2017, about the same as that of 2016. Apparent consumption was virtually unchanged at about 900 million tons. Demand for construction sand and gravel was lower than expected in 2017 because States along the Gulf Coast and in the Southeast were hit by powerful hurricanes, Harvey and Irma, which temporarily led to decreased demand and production in these areas. Long-term increases in construction aggregates demand will be influenced by activity in the public and private construction sectors, as well as by construction work related to security measures being implemented around the Nation. The underlying factors that would support a rise in prices of construction sand and gravel are expected to be present in 2018, especially in and near metropolitan areas.

The construction sand and gravel industry remained concerned with environmental, health, permitting, safety, and zoning regulations. Movement of sand and gravel operations away from densely populated regions was expected to continue where regulations and local sentiment discouraged them. Resultant regional shortages of construction sand and gravel would likely result in higher-than-average price increases in industrialized and urban areas.

World Mine Production and Reserves:

	Mine production[e]		Reserves[6]
	2016	2017	
United States	892	890	Reserves are controlled largely by land use and (or) environmental concerns.
Other countries[7]	NA	NA	
World total	NA	NA	

World Resources: Sand and gravel resources of the world are plentiful. However, because of environmental regulations, geographic distribution, and quality requirements for some uses, sand and gravel extraction is uneconomic 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 2017.

[e]Estimated. NA Not available.
[1]See also Sand and Gravel (Industrial) and Stone (Crushed).
[2]Less than ½ unit.
[3]Defined as production + 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 noted)

Domestic Production and Use: In 2017, industrial sand and gravel valued at about $3.5 billion was produced by about 200 companies from 340 operations in 35 States. The value of production of industrial sand and gravel in 2017 increased by 32% compared to the previous year, owing primarily to increased activity in the oil and gas sector. Leading States were, in order of tonnage produced, Wisconsin, Texas, Illinois, Missouri, North Carolina, Oklahoma, Michigan, Minnesota, California, and Tennessee. Combined production from these States accounted for 87% of the domestic total. About 63% of the U.S. tonnage was used as hydraulic-fracturing sand and well-packing and cementing sand; 10% as other whole-grain silica; 10% as glassmaking sand; 6% as foundry sand; 3% as whole-grain fillers and building products; 2%, each, as other ground silica, and recreational sand; 1% as ground and unground sand for chemicals; and 3% for other uses.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production	62,100	110,000	102,000	77,700	105,000
Imports for consumption	161	245	289	281	310
Exports	2,960	4,470	3,910	2,780	5,200
Consumption, apparent[2]	59,300	106,000	98,400	75,200	100,000
Price, average value, dollars per ton	55.80	74.80	47.30	33.80	33.00
Employment, quarry and mill, number[e]	3,800	4,000	3,500	3,500	4,000
Net import reliance[3] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Some foundry sand is recycled, and recycled cullet (pieces of glass) represents a significant proportion of reused silica. About 34% of glass containers are recycled.

Import Sources (2013–16): Canada, 88%; Mexico, 3%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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 100 million tons in 2017, a 33% increase from that of the previous year, owing primarily to increased activity in the oil and gas sector. Mine output was sufficient to accommodate many uses, which included abrasives, ceramics, chemicals, fillers (ground and whole grain), glassmaking sand, filtration sand for swimming pools, foundry sand, other ground silica, recreational sand, roofing granules and fillers, and sand for well packing and cementing. Increased oil and gas drilling in North America and completion activity triggered a corresponding increase in the production of hydraulic-fracturing sand in 2017 compared with that of the previous year. More efficient hydraulic-fracturing techniques, which require more silica sand use per well (mostly for secondary recovery at mature wells) also led to increased demand for hydraulic-fracturing sand. Imports of industrial sand and gravel in 2017 increased by 10% to about 310,000 tons from 281,000 tons in 2016. Imports of silica are generally of two types—small shipments of very high-purity silica or a few large shipments of lower grade silica shipped only under special circumstances (for example, very low freight rates). The United States remains a net exporter of industrial sand and gravel—exports of industrial sand and gravel increased by 87% in 2017 compared with those of 2016.

The United States was the world's leading producer and consumer of industrial sand and gravel based on estimated world production figures. It is difficult to collect definitive data on silica sand and gravel production in most nations because of the wide range of terminology and specifications found among different countries. The United States remained a major exporter of silica sand and gravel, shipping it to almost every region of the world. The high level of exports was attributed to the high quality and advanced processing techniques used in the United States for many grades of silica sand and gravel, meeting virtually every specification.

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SAND AND GRAVEL (INDUSTRIAL)

The industrial sand and gravel industry continued to be concerned with safety and health regulations and environmental restrictions in 2017, especially those concerning crystalline silica exposure. The Occupational Safety and Health Administration finalized new regulations to further restrict exposure to crystalline silica at mine sites and other industries that use it. Phased implementation of the new regulations is scheduled to take effect from 2017 through 2021. Local shortages of industrial sand and gravel were expected to continue to increase owing to local zoning regulations and land development priorities, including ongoing development and permitting of operations producing hydraulic-fracturing sand. Natural gas and petroleum operations that use hydraulic fracturing may also undergo increased scrutiny. These factors may result in future sand and gravel operations being located farther from high-population centers.

World Mine Production and Reserves:

	Mine production[e]		Reserves[4]
	2016	2017	
United States	77,700	105,000	Large. Industrial sand and gravel deposits are widespread.
Australia	3,000	3,000	
Canada	2,100	2,100	
France	8,800	8,800	
Germany	7,500	7,500	
India	8,000	8,000	
Italy	13,900	13,900	
Japan	2,900	2,900	
Malaysia	10,400	10,400	
Mexico	1,700	1,700	
Poland	2,700	2,700	
South Africa	1,900	1,900	
Spain	6,300	6,300	
Turkey	8,000	8,000	
United Kingdom	4,000	4,000	
Other countries	20,000	20,000	
World total (rounded)	180,000	210,000	

World Resources: 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 uneconomic. 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 and for foundry and molding sands are chromite, olivine, staurolite, and zircon sands. Although more costly 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 Sand and Gravel (Construction).
[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.

SCANDIUM[1]

(Data in metric tons of scandium oxide content unless otherwise noted)

Domestic Production and Use: Domestically, scandium-bearing minerals were neither mined nor recovered from mine tailings in 2016. Scandium that was previously produced domestically was 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 source for scandium metal and scandium compounds was imports from China.

The principal uses for scandium in 2017 were in aluminum-scandium alloys and solid oxide fuel cells (SOFCs). Other uses for scandium included ceramics, electronics, lasers, lighting, and radioactive isotopes. In SOFCs, electricity is generated directly from oxidizing a fuel. Scandium is added to a zirconia-base electrolyte to improve the power density and lower the reaction temperature of the cell. For metal applications, scandium metal is typically produced by reducing scandium fluoride with calcium metal. Aluminum-scandium alloys are produced for sporting goods, aerospace, and other high-performance applications. Scandium is used in small quantities in a number of electronic applications. Some lasers that contain scandium are used in defense applications and in dental treatments. In lighting, scandium iodide is used in mercury-vapor high-intensity lights to simulate natural light. Scandium isotopes are used as a tracing agent in oil refining.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Price, yearend, dollars:					
Compounds, per gram:					
Acetate, 99.9% purity, 5-gram sample size[2]	51.90	43.00	43.00	44.00	44.00
Chloride, 99.9% purity, 5-gram sample size[2]	148.00	123.00	123.00	126.00	124.00
Fluoride, 99.9% purity, 1-to-5-gram sample size	[2]253.00	[2]263.00	[2]263.00	[3]270.00	277.00
Iodide, 99.999% purity, 5-gram sample size[2]	228.00	187.00	187.00	149.00	183.00
Oxide, 99.99% purity, 5-kilogram lot size[4]	5.00	5.00	5.10	4.60	4.60
Metal:					
Scandium, distilled dendritic, per gram, 2-gram sample size[2]	213.00	221.00	221.00	228.00	226.00
Scandium, ingot, per gram, 5-gram sample size[2]	175.00	134.00	134.00	107.00	132.00
Scandium-aluminum alloy, per kilogram, metric-ton lot size[4]	155.00	386.00	220.00	340.00	350.00
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2013–16): Although no definitive data exist listing import sources, imported material is mostly from China.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–17**
Rare-earth metals, unspecified, whether or not intermixed or interalloyed	2805.30.0090	5.0% ad val.
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 val.
Mixtures of other rare-earth compounds, including scandium	2846.90.8090	3.7% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

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SCANDIUM

Events, Trends, and Issues: The global supply and consumption of scandium was estimated to be about 10 tons to 15 tons per year. Consumption of scandium contained in SOFCs and nonferrous alloys was reported to be increasing. The global scandium market remained small relative to most other metals, but the number of supply sources was increasing. In the United States, developers of multimetallic deposits, including the Bokan project in Alaska, the Round Top project in Texas, and the Elk Creek project in Nebraska, were planning to include scandium recovery in their project plans. Owners of the Elk Creek project announced a completed feasibility study, compliant with Canadian National Instrument 43-101, that was based on probable reserves of about 32 million tons of ore containing about 72 grams per ton of scandium. Concurrently, the Department of Energy was partnering with industry and academia to study the recovery of scandium and other rare-earth elements from coal and coal byproducts.

In Australia, a mining lease was granted for the Nyngan scandium project in New South Wales. Reserves at Nyngan were estimated to be 1.44 million tons containing about 590 tons of scandium using an effective cutoff grade of 155 parts per million scandium. Subject to financing, the developer expected to begin production in 2019 and was expected to produce as much as 38.5 tons per year of scandium oxide. Also in New South Wales, developers of the Syerston project were expecting to complete a feasibility study by yearend that would advance offtake agreements and project financing. The Syerston project's measured and indicated scandium resources increased 63% to 45.7 million tons containing 19,200 tons of scandium oxide equivalent using a 300-parts-per-million scandium cutoff grade. In Queensland, ownership of the Scandium-Cobalt-Nickel (SCONI) Project was consolidated and a 20-ton trial of ore was being processed at a demonstration plant. The measured and indicated resources of the SCONI Project were estimated at 12 million tons containing about 3,000 tons of scandium oxide using a 162-parts-per-million scandium cutoff grade. A feasibility study to help secure project financing was scheduled to be completed in 2018. In China, scandium oxide production capacity was reported to be expanding beyond 100 tons per year. In India, environmental clearance was being sought from the State of Odisha for a project to construct a 2.4-ton-per-year scandium oxide plant. India's scandium production was expected to be a byproduct of titanium dioxide production. The project also included a ferroalloy operation and a coal-fired powerplant. In the Philippines, construction of a commercial plant to recover 7.5 tons per year of scandium oxide equivalent from the leaching of nickel laterite for nickel-cobalt sulfide was underway at the Taganito high-pressure acid-leach facility. Production of an intermediate concentrate was expected to begin in 2018. Conversion of the intermediate product to scandium oxide was expected to take place at the Harima operation in Japan. In Russia, pilot-plant studies at an aluminum smelter in the Ural Mountains were ongoing. The pilot plant was reported to have produced scandium oxide with purity greater than 99%. Based on pilot test results, plans were in place for a commercial plant with 3 tons per year of scandium oxide production capacity. In Lermontov, Kurgan region, pilot studies were underway to test scandium recovery as a byproduct of uranium production. Previous studies produced a scandium fluoride concentrate from pregnant solutions. A 1.5-ton-per-year pilot plant was expected to produce finished scandium oxide in 2017. Future plans were to produce aluminum-scandium master alloys. In the European Union, recovery methods were being developed for the production of scandium compounds and aluminum alloys from metallurgical byproducts. In Turkey, one company was developing byproduct scandium recovery from laterite at an existing high-pressure acid-leach operation.

World Mine Production and Reserves:[6] No scandium was mined 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. In recent years, scandium was produced as byproduct material in China (titanium and rare earths), Kazakhstan (uranium), Russia (apatite), and Ukraine (uranium). Foreign mine production data for 2017 were not available.

World Resources: Resources of scandium are 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. There are identified scandium resources in Australia, Canada, China, Kazakhstan, Madagascar, Norway, the Philippines, Russia, Ukraine, and the United States.

Substitutes: Titanium and aluminum high-strength alloys, as well as carbon-fiber materials, may substitute in high-performance scandium-alloy applications. Light-emitting diodes displace mercury-vapor high-intensity lights in some industrial and residential applications. In some applications that rely on scandium's unique properties, substitution is not possible.

[e]Estimated.
[1]See also Rare Earths.
[2]Prices from Alfa Aesar, a Johnson Matthey company.
[3]Prices from Sigma-Aldrich, a part of Millipore Sigma.
[4]Prices from Stanford Materials Corp.
[5]Defined as imports – exports + adjustments for stock changes.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.

SELENIUM

(Data in metric tons of selenium content unless otherwise noted)

Domestic Production and Use: Primary selenium was refined from anode slimes recovered from the electrolytic refining of copper. Of the two electrolytic copper refineries operating in the United States, one reported production of primary selenium, and one exported semirefined selenium for toll refining in Asia.

In glass manufacturing, selenium is used to decolorize the green tint caused by iron impurities in container glass and other soda-lime silica glass and is used in architectural plate glass to reduce solar heat transmission. Cadmium sulfoselenide pigments are used in plastics, ceramics, and glass to produce a ruby-red color. Selenium is used in catalysts to enhance selective oxidation; in plating solutions, where it improves appearance and durability; in blasting caps; in gun bluing to improve cosmetic appearance and provide corrosion resistance; in rubber compounding chemicals to act as a vulcanizing agent; in the electrolytic production of manganese to increase yields; in thin-film photovoltaic copper-indium-gallium-diselenide (CIGS) solar cells; and in copper, lead, and steel alloys to improve machinability.

Selenium is an essential micronutrient and is used as a human dietary supplement, a dietary supplement for livestock, and as a fertilizer additive to enrich selenium-poor soils. Selenium also is used as an active ingredient in antidandruff shampoos.

Estimates for world consumption are as follows: metallurgy (including manganese production), 40%; glass manufacturing, 25%; agriculture, 10%; chemicals and pigments, 10%; electronics, 10%; and other uses, 5%.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production, refinery	W	W	W	W	W
Imports for consumption, metal and dioxide	435	475	457	433	500
Exports, metal[1]	648	521	468	150	335
Consumption, apparent[2]	W	W	W	W	W
Price, average, dollars per pound[3]	36.08	26.78	22.09	23.69	10.80
Stocks, producer, refined, yearend	W	W	W	W	W
Net import reliance[4] as a percentage of apparent consumption	E	E	E	E	E

Recycling: Domestic production of secondary selenium was estimated to be very small because most scrap from older plain paper photocopiers and electronic materials was exported for recovery of the contained selenium.

Import Sources (2013–16): China, 18%; Japan, 16%; Germany, 13%; Philippines, 11%; and other, 42%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–17**
Selenium metal	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 the materials from which it is a byproduct—copper, and to a lesser extent, nickel—and it is directly affected by the number of facilities that recover selenium. The estimated Platts Metals Week annual average New York dealer price for selenium was $10.80 per pound in 2017, about 54% less than the annual average price in 2016. During the fourth quarter of 2016, the average price of selenium decreased dramatically from $34.00 per pound in October to $8.50 per pound in December. Average monthly prices in 2017 increased steadily from $8.50 per pound in January to $11.70 per pound in August.

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SELENIUM

The decrease in exports of selenium in 2016 and 2017 is thought to be the result of incomplete data. Common forms of selenium, such as copper selenide or zinc selenide, may be exported under incorrect Schedule B numbers, and thus not reflected properly in export statistics. The United States is still considered to be a net exporter of selenium despite these lower export values.

In China, official investigations into possible fraudulent activities related to the Fanya Metal Exchange Co. Ltd. (FME) continued in 2017. About 338 tons of selenium were reportedly held in FME warehouses prior to the exchange's shutdown in 2015. As of September 2017, no information was available on how or when the material would be released into the market.

Electrolytic manganese production was the main metallurgical end use for selenium in China, where selenium dioxide was used in the electrolytic process to increase current efficiency and the metal deposition rate. Selenium consumption in China was thought to have increased in recent years; 47 electrolytic manganese producers were reported to have been operating in 2016 (latest information available), up from 26 reported in June 2015.

World Refinery Production and Reserves:

	Refinery production[5]		Reserves[6]
	2016	2017[e]	
United States	W	W	10,000
Belgium	200	200	—
Canada	176	150	6,000
China	920	930	26,000
Finland	96	95	—
Germany	700	710	—
Japan	752	760	—
Peru	45	50	13,000
Poland	87	90	3,000
Russia	145	150	20,000
Sweden	100	100	—
Other countries	47	50	21,000
World total (rounded)	[7]3,270	[7]3,300	100,000

World Resources: Reserves for selenium are based on identified copper deposits and average selenium content. Coal generally contains between 0.5 and 12 parts per million of selenium, or about 80 to 90 times the average for copper deposits. The recovery of selenium from coal fly ash, although technically feasible, does not appear likely to be economical in the foreseeable future.

Substitutes: Silicon is the major substitute for selenium in low- and medium-voltage rectifiers. Organic pigments have been developed as substitutes for cadmium sulfoselenide pigments. Other substitutes include cerium oxide as either a colorant or decolorant in glass; tellurium in pigments and rubber; bismuth, lead, and tellurium in free-machining alloys; and bismuth and tellurium in lead-free brasses. Sulfur dioxide can be used as a replacement for selenium dioxide in the production of electrolytic manganese metal, but it is not as energy efficient.

The selenium-tellurium photoreceptors used in some plain paper copiers and laser printers have been replaced by organic photoreceptors in newer machines. Amorphous silicon and cadmium telluride are the two principal competitors with CIGS in thin-film photovoltaic solar cells.

[e]Estimated. E Net exporter. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]There was no exclusive domestic export classification code for selenium dioxide.
[2]Defined as production + imports – exports + adjustments for industry stock changes.
[3]U.S. spot market price for selenium metal powder, minimum 99.5% purity, in 5-ton lots. Source: Platts Metals Week.
[4]Defined as imports – exports + adjustments for industry stock changes.
[5]Insofar as possible, data relate to refinery output only; thus, countries that produced selenium contained in copper ores, copper concentrates, blister copper, and (or) refinery residues but did not recover refined selenium from these materials indigenously were excluded to avoid double counting.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]Excludes U.S. production. Australia, Iran, Kazakhstan, Mexico, the Philippines, and Uzbekistan are known to produce refined selenium, but output was not reported, and information was inadequate to make reliable production estimates.

SILICON

(Data in thousand metric tons of silicon content unless otherwise noted)

Domestic Production and Use: Five companies produced silicon materials at eight plants, all east of the Mississippi River. 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. The semiconductor and solar energy industries, which manufacture chips for computers and photovoltaic cells from high-purity silicon, respectively, accounted for only a small percentage of silicon demand.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production:					
Ferrosilicon and silicon metal[1, 2]	392	401	411	384	405
Imports for consumption:					
Ferrosilicon, all grades[1]	157	186	162	155	150
Silicon metal	118	139	140	122	140
Exports:					
Ferrosilicon, all grades[1]	10	9	9	7	10
Silicon metal	38	45	37	60	62
Consumption, apparent:[3]					
Ferrosilicon, all grades[1]	W	W	W	W	W
Silicon metal[2]	W	W	W	W	W
Total	631	670	661	601	625
Price, average, cents per pound:					
Ferrosilicon, 50% Si[4]	103	108	101	83	92
Ferrosilicon, 75% Si[5]	94	98	88	71	83
Silicon metal[2, 5]	122	140	127	91	110
Stocks, producer, yearend:					
Ferrosilicon and metal[1, 2]	25	27	33	27	25
Net import reliance[6] as a percentage of apparent consumption:					
Ferrosilicon, all grades[1]	<50	<50	>50	>50	<50
Silicon metal[2]	<50	<50	<50	<50	<50
Total	39	42	38	36	35

Recycling: Insignificant.

Import Sources (2013–16): Ferrosilicon: Russia, 36%; China, 23%; Canada, 12%; Venezuela, 9%; and other, 20%. Silicon metal: South Africa, 25%; Brazil, 24%; Canada and Australia, 14% each; and other, 23%. Total: Russia, 20%; Brazil, Canada, and China, 13% each; and other, 41%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Silicon, more than 99.99% Si	2804.61.0000	Free.
Silicon, 99.00%–99.99% Si	2804.69.1000	5.3% ad val.
Silicon, other	2804.69.5000	5.5% ad val.
Ferrosilicon, 55%–80% Si:		
More than 3% Ca	7202.21.1000	1.1% ad val.
Other	7202.21.5000	1.5% ad val.
Ferrosilicon, 80%–90% Si	7202.21.7500	1.9% ad val.
Ferrosilicon, more than 90% Si	7202.21.9000	5.8% ad val.
Ferrosilicon, other:		
More than 2% Mg	7202.29.0010	Free.
Other	7202.29.0050	Free.

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SILICON

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 2017, expressed in terms of contained silicon, increased from that of 2016. Domestic production during the first 9 months of 2017 was slightly more than that during the same period in 2016. By September 2017, average U.S. ferrosilicon spot market prices had increased by 11% and 18%, for 50%-grade and 75%-grade ferrosilicon, respectively, and the average silicon metal spot market price had increased by 21% compared with the annual average spot prices in 2016. The increase in silicon metal prices was attributed to preliminary rulings of ongoing trade cases. Owing to increasing demand and continuing trade cases, operations in Argentina, South Africa, and the United States that had been operating below capacity were restarting, or planning to restart, full operations.

Excluding the United States, ferrosilicon accounts for about 61% of world silicon production on a silicon-content basis. The leading countries for ferrosilicon production were, in descending order and on a contained-weight basis, China, Russia, and Norway. For silicon metal, the leading producers were China, Norway, and France. China accounted for approximately 65% of total global estimated production of silicon materials in 2017.

World Production and Reserves:

	Production[e, 7] 2016	Production[e, 7] 2017	Reserves[8]
United States	[9]384	405	The reserves in most major producing countries are ample in relation to demand. Quantitative estimates are not available.
Bhutan[10]	69	69	
Brazil	110	110	
Canada	51	51	
China	5,000	4,800	
France	120	120	
Iceland[10]	79	79	
India[10]	59	59	
Malaysia[10]	82	110	
Norway	380	380	
Russia	750	750	
South Africa	85	85	
Spain	81	75	
Ukraine[10]	66	61	
Other countries	310	280	
World total (rounded)	7,600	7,400	

World Resources: 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. W Withheld to avoid disclosing company proprietary data.
[1]Ferrosilicon grades include the two standard grades of ferrosilicon—50% and 75% silicon—plus miscellaneous silicon alloys.
[2]Metallurgical-grade silicon metal.
[3]Defined as production + imports – exports + adjustments for industry stock changes.
[4]CRU Group transaction prices based on weekly averages.
[5]S&P Global Platts mean import prices based on monthly averages.
[6]Defined as imports – exports + adjustments for industry stock changes.
[7]Production quantities are the silicon content of combined totals for ferrosilicon and silicon metal, except as noted.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.
[9]Reported figure.
[10]Silicon content of ferrosilicon only.

SILVER

(Data in metric tons[1] of silver content unless otherwise noted)

Domestic Production and Use: In 2017, U.S. mines produced approximately 1,020 tons of silver with an estimated value of $564 million. Silver was produced at 4 silver mines and as a byproduct or coproduct from 36 domestic base- and precious-metal mines. Alaska continued as the country's leading silver-producing State, followed by Nevada. There were 24 U.S. refiners that reported production of commercial-grade silver with an estimated total output of 1,950 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 2017, the estimated domestic uses for silver were electrical and electronics, 36%; coins and medals, 22%; jewelry and silverware, 7%; photography, 5%; and other, 30%. 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; photovoltaic solar cells; water purification; and wood treatment. Mercury and silver, the main components of dental amalgam, are biocides, and their use in amalgam inhibits recurrent decay.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production:					
Mine	1,040	1,180	1,090	1,150	1,020
Refinery:					
Primary	800	800	800	800	800
Secondary (new and old scrap)	1,700	1,400	1,200	1,300	1,150
Imports for consumption[2]	5,080	5,000	5,930	6,160	5,270
Exports[2]	409	380	818	289	160
Consumption, apparent[3]	6,670	6,920	8,000	7,600	5,770
Price, average, dollars per troy ounce[4]	23.89	19.09	15.72	17.20	17.20
Stocks, yearend:					
Industry	110	120	130	140	150
Treasury Department[5]	498	498	498	498	498
New York Commodities Exchange—COMEX	5,350	5,610	5,000	5,710	7,210
Employment, mine and mill, number[6]	1,284	1,185	1,204	1,189	959
Net import reliance[7] as a percentage of apparent consumption	59	63	71	68	62

Recycling: In 2017, approximately 1,150 tons of silver was recovered from new and old scrap, about 20% of apparent consumption.

Import Sources (2013–16):[2] Mexico, 48%; Canada, 32%; Peru, 5%; Poland, 4%; and other, 11%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Silver ores and concentrates, silver content	2616.10.0040	0.8 ¢/kg on lead content.
Bullion, silver content	7106.91.1010	Free.
Dore, silver content	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 2017 was unchanged from the average price in 2016. The price began the year at $16.03 per troy ounce, increased to a high of $18.56 per troy ounce on April 13, and then fell to a low of $15.34 per troy ounce on July 10. The silver price range over the course of 2017 narrowed in comparison with that in 2016, which saw slightly more than double the dollar difference between the high and low prices.

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SILVER

In 2017, global consumption of silver was estimated to have decreased by 5% from that of 2016. A significant decrease in silver consumption for coins and bars, which was projected to fall to a 10-year low following record high sales in 2015, was slightly offset by increased consumption for industrial fabrication, jewelry fabrication, and silverware. Of the industrial uses, consumption of silver for brazing and alloys, electronics, ethylene oxide, and solar applications was expected to increase in 2017.[8] Global yearend stocks of refined silver continued to increase and were projected to be at a 10-year high for a second consecutive year owing to a reduction of consumption in physical silver.

World silver mine production decreased in 2017 to 25,000 tons, principally as a result of decreased production from mines in Argentina, Australia, Bolivia, Chile, Peru, and the United States. The world's top silver-producing companies experienced reductions in production owing to governmental issues with licensing, reduced ore grades, and worker strikes at various projects. Domestic silver mine production decreased by 11% in 2017 compared with that in 2016 largely owing to a strike at one of the four primary silver mines in the United States, which began in the second quarter of 2017. With physical demand down and a relatively moderate price for silver, the development of new projects has slowed as well.

World Mine Production and Reserves: Reserves for Chile, Peru, Poland, and Russia were revised based on new information from official Government sources.

	Mine production		Reserves[9]
	2016	2017[e]	
United States	1,150	1,020	25,000
Australia	1,420	1,200	[10]89,000
Bolivia	1,350	1,200	22,000
Chile	1,500	1,200	27,000
China	2,380	2,500	39,000
Kazakhstan	1,180	1,200	NA
Mexico	5,360	5,600	37,000
Peru	4,370	4,500	93,000
Poland	1,270	1,400	89,000
Russia	1,570	1,600	55,000
Other countries	4,100	3,600	57,000
World total (rounded)	25,700	25,000	530,000

World Resources: Although silver was a principal product at several mines, silver was primarily obtained as a byproduct from lead-zinc mines, copper mines, and gold mines, in descending order of 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, 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. Series has been updated to include changes in COMEX stocks.

[4]Engelhard's industrial bullion quotations. Source: Platts Metals Week.

[5]Balance in U.S. Mint only; includes deep storage and working stocks.

[6]Source: U.S. Department of Labor, Mine Safety and Health Administration. Only includes mines where silver is the primary product;.

[7]Defined as imports – exports + adjustments for Government and industry stock changes.

[8] Wiebe, Johann, 2017, Silver survey update 2017—The Silver Institute—2017 interim report: GFMS, Thompson Reuters, November 15, 35 p.

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

[10]For Australia, Joint Ore Reserves Committee-compliant reserves were about 26,000 tons.

SODA ASH

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: The total value of domestic natural soda ash (sodium carbonate) produced in 2017 was estimated to be about $1.8 billion.[1] U.S. production of 11.8 million tons was equal to that of the previous year but about 600,000 tons higher than production in 2012. The U.S. soda ash industry comprised four companies in Wyoming operating five plants and one company in California with one plant. The five producing companies have a combined annual nameplate capacity of 13.7 million tons (15.2 million short tons). 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 2017 quarterly reports, the estimated distribution of soda ash by end use was glass, 49%; chemicals, 28%; distributors, 6%; soap and detergents, 6%; miscellaneous uses, 5%; flue gas desulfurization, 4%; pulp and paper, 1%; and water treatment, 1%.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production[2]	11,500	11,700	11,600	11,800	11,800
Imports for consumption	13	39	40	35	24
Exports	6,460	6,670	6,400	6,780	6,870
Consumption:					
Apparent[3]	5,000	5,100	5,200	5,010	4,950
Reported	5,120	5,170	4,990	5,120	4,900
Price:					
Average sales value (natural source):					
f.o.b. mine or plant, dollars per metric ton	145.18	148.67	155.30	149.83	152.00
f.o.b. mine or plant, dollars per short ton	131.71	134.87	140.88	135.92	138.00
Stocks, producer, yearend	348	271	285	336	296
Employment, mine and plant, number[e]	2,500	2,500	2,500	2,500	2,500
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 are using cullet glass, thereby reducing soda ash consumption.

Import Sources (2013–16): Germany, 52%; Italy, 17%; United Kingdom, 13%; Mexico, 6%; and other, 12%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Disodium carbonate	2836.20.0000	1.2% ad val.

Depletion Allowance: Natural, 14% (Domestic and foreign).

Government Stockpile: None.

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SODA ASH

Events, Trends, and Issues: Relatively low production costs and lower environmental impacts provide natural soda ash producers 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. In recent years, U.S. producers of natural soda ash were able to expand their markets when several synthetic soda ash plants were closed or idled around the world.

Soda ash production in Turkey rose in 2017 as a new 2.5-million-ton-per-year plant was opened in the second half of the year. Total production capacity in Turkey is estimated to be between 4 and 5 million tons and soda ash shipments, especially for export, are expected to increase significantly over the next few years.

Three groups dominate production and have become the world's leading suppliers of soda ash—American National Soda Ash Corp., which represented three of the five domestic producers in 2017; multiple producers in China; and Solvay S.A. of Belgium. The United States likely will remain competitive with producers in China for markets elsewhere in Asia. Asia and South America remain the most likely areas for increased soda ash consumption in the near future. U.S. producers expect modest growth in production and exports through 2020.

World Production and Reserves: Reserves for Turkey were revised based on new Government information.

	Mine production		Reserves[5, 6]
Natural:	2016	2017[e]	
United States	11,800	11,800	[7]23,000,000
Botswana	250	250	400,000
Kenya	450	450	7,000
Turkey	1,900	2,100	840,000
Other countries	—	15,000	280,000
World total, natural (rounded)	14,400	15,000	25,000,000
World total, synthetic (rounded)	39,200	39,000	XX
World total (rounded)	53,600	54,000	XX

World Resources: 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 815 million tons of soda ash reserves. At least 95 natural sodium carbonate deposits have been identified in the world, 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 more costly 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. XX Not applicable. — Zero.
[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 yields 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.

STONE (CRUSHED)[1]

(Data in million metric tons unless otherwise noted)

Domestic Production and Use: In 2017, 1.33 billion tons of crushed stone valued at more than $15 billion was produced by an estimated 1,400 companies operating 3,700 quarries and 187 sales/distribution yards in 50 States. Leading States were, in descending order of production, Texas, Pennsylvania, Florida, North Carolina, Ohio, Missouri, Georgia, Kentucky, Virginia, and Indiana, which together accounted for more than one-half of the total crushed stone output. Of the total domestic crushed stone produced in 2017, about 70% was limestone and dolomite; 13%, granite; 6%, traprock; 5%, miscellaneous stone; 4%, sandstone and quartzite; and the remaining 2% was divided, in descending order of tonnage, among marble, volcanic cinder and scoria, calcareous marl, slate, and shell. It is estimated that of the 1.39 billion tons of crushed stone consumed in the United States in 2017, 76% was used as construction material, mostly for road construction and maintenance; 11% for cement manufacturing; 7% for lime manufacturing; 4% for other chemical, special, and miscellaneous uses and products; and 2% for agricultural uses.

The estimated output of crushed stone in the United States shipped for consumption in the first 9 months of 2017 was 1.01 billion tons, a slight decrease compared with that of the same period of 2016. Third quarter shipments for consumption decreased slightly compared with those of the same period of 2016. Additional production information, by quarter for each State, geographic division, and the United States, is reported in the U.S. Geological Survey quarterly Mineral Industry Surveys for Crushed Stone and Sand and Gravel.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production	1,200	1,250	1,330	1,360	1,330
Recycled material	41	36	37	38	38
Imports for consumption	16	18	20	20	18
Exports	([2])	([2])	([2])	1	1
Consumption, apparent[3]	1,250	1,310	1,380	1,410	1,390
Price, average value, dollars per metric ton	9.94	10.21	10.56	11.14	11.45
Employment, quarry and mill, number[4]	65,900	65,600	67,100	68,100	67,900
Net import reliance[5] as a percentage of apparent consumption	1	2	1	1	1

Recycling: Road surfaces made of asphalt and crushed stone and portland cement concrete surface layers and structures were recycled on a limited but increasing basis in most States. Asphalt road surfaces and concrete were recycled in all 50 States.

Import Sources (2013–16): Mexico, 56%; Canada, 28%; The Bahamas, 10%; Honduras, 5%; and other, 1%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
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: (Domestic) 14% for some special uses; 5%, if used as ballast, concrete aggregate, riprap, road material, and similar purposes.

Government Stockpile: None.

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STONE (CRUSHED)

Events, Trends, and Issues: Crushed stone production was about 1.33 billion tons in 2017, a slight decrease compared with that of 2016. Apparent consumption also decreased to about 1.39 billion tons. Demand for crushed stone was lower in 2017 because States along the Gulf Coast and in the Southeast were affected by Hurricanes Harvey and Irma, which led to decreased demand and production in these areas. Long-term increases in construction aggregates demand will be influenced by activity in the public and private construction sectors, as well as by construction work related to security measures being implemented around the Nation. The underlying factors that would support a rise in prices of crushed stone are expected to be present in 2018, especially in and near metropolitan areas.

World Mine Production and Reserves:

	Mine production		Reserves[6]
	2016	2017[e]	
United States	1,360	1,330	Adequate, except where special
Other countries[7]	NA	NA	types are needed or where
World total	NA	NA	local shortages exist.

World Resources: Stone resources of the world are very large. 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.

Substitutes: 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.

[e]Estimated. NA Not available.
[1]See also Sand and Gravel (Construction) and Stone (Dimension).
[2]Less than ½ unit.
[3]Defined as production + 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]Consistent production information is not available for other countries owing to a 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 noted)

Domestic Production and Use: Approximately 2.73 million tons of dimension stone, valued at $440 million, was sold or used by U.S. producers in 2017. Dimension stone was produced by 205 companies, operating 275 quarries, in 34 States. Leading producer States were, in descending order by tonnage, Texas, Indiana, Wisconsin, Massachusetts, and Georgia. These five States accounted for about 69% of the production and contributed about 59% of the value of domestic production. Approximately 54%, by tonnage, of dimension stone sold or used was limestone, followed by granite (21%), sandstone (14%), miscellaneous stone (8%), marble (2%), and slate (1%). By value, the leading sales or uses were for limestone (41%), followed by granite (29%), sandstone (11%), miscellaneous stone (10%), marble (5%), and slate (4%). Rough stone represented 58% of the tonnage and 44% 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 (48%) and in irregular-shaped stone (40%). The leading uses and distribution of dressed stone, by tonnage, were in ashlars and partially squared pieces (39%), curbing (14%), and other uses (13%).

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Sold or used by producers[2]					
Tonnage	2,280	2,470	2,630	2,780	2,730
Value, million dollars	459	470	461	445	440
Imports for consumption, value, million dollars	2,100	2,230	2,380	2,170	2,200
Exports, value, million dollars	61	70	75	66	71
Consumption, apparent, value, million dollars[3]	2,500	2,630	2,760	2,550	2,570
Price	Variable, depending on type of product				
Employment, quarry and mill, number[4]	4,000	4,000	4,000	4,000	3,900
Net import reliance[5] as a percentage of apparent consumption (based on value)	82	82	84	83	83
Granite only, sold or used by producers:					
Tonnage	496	519	585	593	590
Value, million dollars	132	117	130	130	130
Imports, value, million dollars	1,300	1,330	1,330	1,110	1,060
Exports, value, million dollars	30	32	27	21	23
Consumption, apparent, value, million dollars[3]	1,400	1,420	1,430	1,220	1,170
Price	Variable, depending on type of product				
Employment, quarry and mill, number[4]	880	880	880	880	880
Net import reliance[5] as a percentage of apparent consumption (based on value)	91	91	91	89	89

Recycling: Small amounts of dimension stone were recycled, principally by restorers of old stone work.

Import Sources (2013–16 by value): All dimension stone: China, 26%; Brazil, 25%; Italy, 22%; Turkey, 12%; and other, 15%. Granite only: Brazil, 47%; China, 23%; India, 15%; Italy, 10%; and other, 5%.

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 2017. Most crude or rough-trimmed stone was imported at 3.0% ad valorem or less.

Depletion Allowance: 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 is one of the world's leading markets for dimension stone. For 2017, total imports of dimension stone remained essentially unchanged in value compared with 2016. In 2017, mixed to slight growth in new residential construction, resulted in lower domestic production of dimension stone compared with the previous year. Dimension stone for construction and refurbishment was used in commercial and residential markets; in 2017, the renovation market for existing homes remained healthy and robust—continuing a trend from the previous year. These factors contributed to a slight rise in dimension stone imports. Dimension stone exports increased to about $71 million. Apparent consumption, by value, was estimated to be $2.6 billion in 2017—a slight increase from that of 2016.

The dimension stone industry continued to be concerned with safety and health regulations and environmental restrictions in 2017, especially those concerning crystalline silica exposure. In 2016, the Occupational Safety and Health Administration finalized new regulations to further restrict exposure to crystalline silica at quarry sites and other industries that use materials containing it. Phased implementation of the new regulations are scheduled to take effect from 2017 through 2021.

According to Italy's Internazionale Marmi e Macchine Carrara S.p.A., world dimension granite and marble production, including the United States, was estimated to be approximately 155 million tons in 2014, the last year for which data were available. Although some small-scale production was likely in many nations, dimension granite and marble was produced and officially reported in 27 countries. The top five producing countries in 2014 were, in descending order by tonnage, China, India, Turkey, Iran, and Italy, and these countries accounted for about 74% of the world's dimension granite and marble production. Global production of dimension granite and marble increased by 12% in 2014 compared with that of 2013. The United States ranked 18th in world production of dimension granite and marble in 2014.

World Mine Production and Reserves:

	Mine production		Reserves[6]
	2016	2017[e]	
United States	2,780	2,730	Adequate except for certain
Other countries	NA	NA	special types and local
World total	NA	NA	shortages.

World Resources: 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 Stone (Crushed).
[2]Includes granite, limestone, and other types of dimension stone.
[3]Defined as sold or used (value) + imports (value) – exports (value).
[4]Excludes office staff.
[5]Defined as imports – exports.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.

STRONTIUM

(Data in metric tons of strontium content unless otherwise noted)

Domestic Production and Use: Although deposits of strontium minerals occur widely throughout the United States, none have been mined in the United States since 1959. Domestic production of strontium carbonate, the principal strontium compound, ceased in 2006. It is thought that virtually all of the strontium mineral celestite consumed in the United States since 2006 has been used as an additive in drilling fluids for oil and natural gas wells.

A few domestic companies produce small quantities of downstream strontium chemicals from imported strontium carbonate. The estimated end-use distribution for strontium compounds in the United States was pyrotechnics and signals, 30%; ceramic ferrite magnets, 30%; and master alloys, pigments and fillers, electrolytic production of zinc, and other applications, including glass, 10% each.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production	—	—	—	—	—
Imports for consumption:					
Celestite[1]	21,900	24,200	24,500	4,420	10,800
Strontium compounds[2]	7,190	7,600	7,100	6,420	6,390
Exports, strontium compounds	37	104	86	91	49
Consumption, apparent:					
Celestite	21,900	24,200	24,500	4,420	10,800
Strontium compounds	7,160	7,500	7,020	6,330	6,340
Total	29,000	31,700	31,500	10,800	17,200
Price, average value of celestite imports at port of exportation, dollars per ton	50	50	51	78	73
Net import reliance[3] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2013–16): Celestite: Mexico, 100%. Strontium compounds: Mexico, 54%; Germany, 39%; China, 6%; and other, 1%. Total imports: Mexico, 87%; Germany, 11%; and China, 2%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Celestite	2530.90.8010	Free.
Strontium compounds:		
Strontium metal	2805.19.1000	3.7% ad val.
Strontium oxide, hydroxide, peroxide	2816.40.1000	4.2% ad val.
Strontium nitrate	2834.29.2000	4.2% ad val.
Strontium carbonate	2836.92.0000	4.2% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

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STRONTIUM

Events, Trends, and Issues: After increasing for 6 consecutive years, imports of celestite, the most commonly used strontium mineral, decreased by about 82% in 2016 before increasing again in 2017, although still below levels from 2013 through 2015. The decrease in 2016 was likely the result of decreased natural gas- and oil-drilling activity owing to low gas and oil prices in 2014 and 2015. The imports of celestite mirrored the rebounding oil prices in 2016 and 2017. All of the celestite is imported from Mexico and is thought to be used exclusively as an additive in drilling fluids for oil and natural gas exploration and production. For these applications, celestite is ground but undergoes no chemical processing. Outside the United States, celestite is the raw material used for production of strontium compounds.

Strontium carbonate is sintered with iron oxide to produce permanent ceramic ferrite magnets. Strontium nitrate contributes a brilliant red color to fireworks and signal flares. Approximately equal quantities of strontium compounds were thought to be used in these end uses. Smaller quantities of strontium compounds were consumed in several other applications, including glass production, electrolytic production of zinc, master alloys, and pigments and fillers. Strontium may be ingested by humans as a dietary supplement, as an active ingredient in toothpastes, and as a pain reliever for some types of cancer. Although specific information is not available, these uses likely consume very small quantities of strontium compounds, but the compounds must be extremely pure and, thus, are of high unit value.

With improvements to global economic conditions, consumption of strontium compounds and, thus, celestite would be expected to increase. Little information is available about the potential for celestite consumption in drilling fluids, but if oil and gas drilling increases, celestite consumption in that end use may increase as well.

World Mine Production and Reserves:[4]

	Mine production		Reserves[5]
	2016	2017[e]	
United States	—	—	—
Argentina	5,000	5,000	All other:
China	50,000	50,000	6,800,000
Mexico	56,500	57,000	
Spain	90,000	90,000	
World total (rounded)	202,000	202,000	6,800,000

World Resources: World resources of strontium are thought to exceed 1 billion tons.

Substitutes: Barium can be substituted for strontium in ferrite ceramic magnets; however, the resulting barium composite will have 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. — Zero.
[1]The strontium content of celestite is 43.88%, assuming an ore grade of 92%, which was used to convert units of celestite to strontium content.
[2]Strontium compounds, with their respective strontium contents, in descending order, include metal (100.00%); oxide, hydroxide, and peroxide (70.00%); carbonate (59.35%); and nitrate (41.40%). These factors were used to convert gross weight of strontium compounds to strontium content.
[3]Defined as imports − exports.
[4]Gross weight of celestite in tons.
[5]See Appendix C for resource and reserve definitions and information concerning data sources.

SULFUR

(Data in thousand metric tons of sulfur unless otherwise noted)

Domestic Production and Use: In 2017, recovered elemental sulfur and byproduct sulfuric acid were produced at 98 operations in 27 States. Total shipments were valued at about $585 million. Elemental sulfur production was 9.03 million tons; Louisiana and Texas accounted for about 54% of domestic production. Elemental sulfur was recovered, in descending order of tonnage, at petroleum refineries, natural-gas-processing plants, and coking plants by 37 companies at 92 plants in 26 States. Byproduct sulfuric acid, representing about 7% of production of sulfur in all forms, was recovered at six nonferrous smelters in five States by four companies. Domestic elemental sulfur provided 66% of domestic consumption, and byproduct acid accounted for about 5%. The remaining 29% 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:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Recovered elemental	8,590	9,050	8,890	9,070	9,030
Other forms	616	587	646	673	630
Total (rounded)	9,210	9,640	9,540	9,740	9,660
Shipments, all forms	9,200	9,670	9,560	9,750	9,750
Imports for consumption:					
Recovered, elemental[e]	2,990	2,370	2,240	1,820	2,010
Sulfuric acid, sulfur content	972	1,000	1,160	1,050	940
Exports:					
Recovered, elemental	1,770	2,010	1,840	2,050	2,260
Sulfuric acid, sulfur content	54	53	58	58	66
Consumption, apparent, all forms[1]	11,300	11,000	11,000	10,500	10,300
Price, reported average value, dollars per ton of elemental sulfur, f.o.b., mine and (or) plant	68.71	80.07	87.62	37.88	60.00
Stocks, producer, yearend	160	141	138	144	136
Employment, mine and (or) plant, number	2,600	2,600	2,600	2,500	2,400
Net import reliance[2] as a percentage of apparent consumption	19	12	14	7	6

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 (2013–16): Elemental: Canada, 81%; Mexico, 11%; Venezuela, 3%; and other, 5%. Sulfuric acid: Canada, 63%; Mexico, 20%; and other, 17%. Total sulfur imports: Canada, 76%; Mexico 14%; Venezuela, 2%; and other, 8%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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 in 2017 was estimated to have decreased slightly from 2016 and shipments were about the same as those of 2016. Domestic production of elemental sulfur from petroleum refineries and recovery from natural gas operations decreased slightly. Domestically, refinery sulfur production is expected to remain relatively constant as well as byproduct sulfuric acid, unless one or more of the remaining nonferrous-metal smelters close. Decreased U.S. sulfur production in 2017 was the result of the hurricanes in the Gulf Coast region that temporarily shut down several refineries and the closure of three facilities in Alabama and Texas.

Domestic phosphate rock consumption was lower in 2017 than in 2016, which resulted in decreased demand for sulfur to process the phosphate rock into phosphate fertilizers.

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SULFUR

World sulfur production was unchanged but is likely to steadily increase for the foreseeable future. The largest increases in sulfur production during the next 5 years are expected to take place in India, Kazakhstan, Kuwait, Malaysia, and Saudi Arabia. New sulfur demand associated with phosphate fertilizer projects is expected in India, Indonesia, Malaysia, Morocco, and Saudi Arabia.

Contract sulfur prices in Tampa, FL, began 2017 at around $110 per ton. The price decreased to $65 per ton at the end of July but increased to about $69 per ton in mid-October. Export prices were higher than domestic prices. In the past few years, sulfur prices have been variable, a result of the volatility of the demand for sulfur.

World Production and Reserves:

	Production—All forms	
	2016	2017[e]
United States	9,740	9,660
Australia	900	900
Brazil	530	530
Canada	5,320	5,300
Chile	1,800	1,800
China	17,750	17,800
Finland	820	820
Germany	3,800	3,800
India	3,130	3,200
Iran	2,200	2,200
Italy	550	550
Japan	3,420	3,400
Kazakhstan	3,120	3,100
Korea, Republic of	2,430	2,400
Kuwait	850	850
Mexico	1,160	1,200
Netherlands	530	530
Poland	1,200	1,200
Qatar	1,900	1,900
Russia	6,960	7,000
Saudi Arabia	4,900	4,900
Turkmenistan	600	600
United Arab Emirates	5,300	5,300
Venezuela	700	700
Other countries	3,200	3,300
World total (rounded)	83,000	83,000

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 should 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: Resources of elemental sulfur in evaporite and volcanic deposits and sulfur associated with natural gas, petroleum, tar sands, and metal sulfides amount to 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 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.

[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.

TALC AND PYROPHYLLITE[1]

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Three companies operated five talc-producing mines in three States during 2017, and domestic production of crude talc was estimated to have increased slightly to 550,000 tons valued at $19 million. Montana was the leading producer State, followed by Texas and Vermont. Total sales (domestic and export) of talc by U.S. producers were estimated to be 540,000 tons valued at $108 million, a slight increase from those in 2016. Talc produced and sold in the United States was used in ceramics (including automotive catalytic converters) (20%), paint (19%), paper (15%), plastics (8%), rubber (5%), refractories (4%), roofing (4%), and cosmetics (3%). The remainder was for export, insecticides, and other miscellaneous uses. Of the estimated 380,000 tons of talc that was imported in 2017, it is likely that more than 75% was used in cosmetics, paint, and plastics applications. Including imported talc, the U.S. end-use rankings were thought to be, in decreasing order by tonnage, plastics, ceramics, paint, paper, roofing, rubber, cosmetics, and other.

One company in North Carolina mined and processed pyrophyllite in 2017. Domestic production was withheld in order to avoid disclosing company proprietary data and was estimated to have increased from that in 2016. Pyrophyllite was sold for refractory, paint, and ceramic products.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, mine	542	608	615	536	550
Sold by producers	560	551	535	527	540
Imports for consumption	275	308	322	378	380
Exports	196	190	206	169	210
Consumption, apparent[2]	621	726	731	745	710
Price, average, milled, dollars per metric ton[3]	163	171	186	193	200
Employment, mine and mill, talc[4]	250	230	239	223	210
Employment, mine and mill, pyrophyllite[4]	23	26	29	30	31
Net import reliance[5] as a percentage of apparent consumption	13	14	16	28	23

Recycling: Insignificant.

Import Sources (2013–16): Pakistan, 35%; Canada, 28%; China, 26%; Japan, 5% (includes pyrophyllite); and other, 6%. Large quantities of crude talc are mined in Afghanistan before being milled in and exported from Pakistan.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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.

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TALC AND PYROPHYLLITE

Events, Trends, and Issues: Canada, China, and Pakistan were the principal import sources for talc in recent years, based on data reported by the U.S. Census Bureau. Imports from China and Pakistan increased annually by an average of 47% and 11%, respectively, in recent years. Canada and Mexico continued to be the primary destinations for U.S. talc shipments, collectively receiving about 65% of exports.

Consumption of talc in several domestic talc markets has declined since peak production of 1.06 million tons in 1995, with the largest decreases taking place in the ceramics (talc use fell by an estimated 54%), paper (40%), roofing (37%), cosmetics (23%), and paint (20%) industries. Ceramic tile and sanitaryware formulations and the technology for firing ceramic tile changed, reducing the amount of talc required for the manufacture of some ceramic products. Many domestic ceramic tile manufacturing plants also closed as tile imports increased, leading a major domestic producer to stop mining talc in 2008. For paint, the industry shifted its focus to production of water-based paint from oil-based paint in order to reduce volatile emissions. Talc is effective in oil-based paints but is not well suited for water-based paints because it is hydrophobic. Paper manufacturing decreased beginning in the 1990s, and some talc used for pitch control was replaced by chemical agents. For cosmetics, manufacturers of body dusting powders shifted some of their production from talc-based to corn-starch-based products. In contrast, sales of domestic talc for plastics rose by an estimated 54% from 1995 to 2017, primarily the result of increased use in automotive plastics, but a significant share of the increased demand has been met with imported talc. The paper industry has traditionally been the largest consumer of talc worldwide, although plastics are expected to overtake paper as the predominant end use within the next several years as Asian papermakers make greater use of talc substitutes and use of talc in automobile plastics increases.

World Mine Production and Reserves:

	Mine production		Reserves[6]
	2016	2017[e]	
United States (crude)	536	550	140,000
Brazil (crude and beneficiated)[7]	850	850	52,000
China (unspecified minerals)	1,800	1,900	Large
France (crude)	450	470	Large
India[7]	1,000	1,000	110,000
Japan[7]	365	370	100,000
Korea, Republic of[7]	600	610	11,000
Mexico	700	650	Large
Other countries	[7]1,680	[7]1,700	Large
World total (rounded)	[7]7,900	[7]8,100	Large

World Resources: The United States is self-sufficient in most grades of talc and related minerals. Domestic and world 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.
[1]All statistics exclude pyrophyllite unless otherwise noted.
[2]Defined as mine production + 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]Includes pyrophyllite.

TANTALUM

(Data in metric tons of tantalum content unless otherwise noted)

Domestic Production and Use: No significant U.S. tantalum mine production has been reported since 1959. Domestic tantalum resources are of low grade, some are mineralogically complex, and most are not commercially recoverable. Companies in the United States produced tantalum alloys, capacitors, compounds, and metal from imported tantalum ores and concentrates, tantalum-containing materials, and metal and alloys were recovered from foreign and domestic scrap. Domestic tantalum consumption is not reported by consumers. Major end uses for tantalum capacitors include automotive electronics, mobile phones, and personal computers. Tantalum oxide (Ta_2O_5) is used in glass lenses to make lighter weight lenses that produce a brighter image. Tantalum carbide is used in cutting tools. The value of tantalum consumed in 2017 was estimated to exceed $240 million as measured by the value of imports.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Mine	—	—	—	—	—
Secondary	NA	NA	NA	NA	NA
Imports for consumption[e, 1]	1,110	1,230	1,240	1,060	1,290
Exports[e, 1]	844	725	657	604	630
Government stockpile releases[e,2]	—	—	—	—	—
Consumption, apparent[3]	263	508	586	458	660
Price, tantalite, dollars per kilogram of Ta_2O_5 content[4]	260	221	193	193	193
Net import reliance[5] as a percentage of apparent consumption	100	100	100	100	100

Recycling: Tantalum was recycled mostly from new scrap that was generated during the manufacture of tantalum-containing electronic components and from tantalum-containing cemented carbide and superalloy scrap.

Import Sources (2013–16): Tantalum minerals: Brazil, 40%; Rwanda, 26%; Australia, 8%; Canada, 7%; and other, 19%. Tantalum metal: China, 23%; Kazakhstan, 12%; Austria, 11%; Indonesia, 8%; and other, 46%. Tantalum waste and scrap: Austria, 20%; China, 17%; Indonesia, 15%; and other 48%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Synthetic tantalum-niobium concentrates	2615.90.3000	Free.
Tantalum ores and concentrates	2615.90.6060	Free.
Tantalum oxide[6]	2825.90.9000	3.7% ad val.
Potassium fluorotantalate[6]	2826.90.9000	3.1% ad val.
Tantalum, unwrought:		
Powders	8103.20.0030	2.5% ad val.
Alloys and metal	8103.20.0090	2.5% ad val.
Tantalum, waste and scrap	8103.30.0000	Free.
Tantalum, other	8103.90.0000	4.4% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: For FY 2018, the Defense Logistics Agency (DLA) Strategic Materials announced a maximum acquisition limit for tantalum materials of about 15 tons. DLA Strategic Materials planned to dispose of or upgrade 1.7 tons of tantalum carbide powder.

Stockpile Status—9–30–17[7]

Material	**Inventory**	**Disposal Plan FY 2017**	**Disposals FY 2017**
Tantalum carbide powder	1.71	1.71	—
Tantalum materials	0.09	—	—

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TANTALUM

Events, Trends, and Issues: U.S. tantalum apparent consumption in 2017 was estimated to have increased 44% from that of 2016. U.S. imports for consumption increased 22% from those of 2016. The increase was largely attributed to the increase in imports of tantalum powders (30% increase) and tantalum waste and scrap (23% increase). U.S. exports increased 4% from those of 2016. In 2017, the average monthly price of tantalum ore remained at about $193 per kilogram of Ta_2O_5 content from January through September. This was unchanged from the average price in 2015. Congo (Kinshasa) and Rwanda accounted for about 60% of estimated global tantalum production in 2017.

A company in Australia announced that its Bald Hill lithium and tantalum mine was fully funded, and production in Western Australia was expected to start in 2018. Bald Hill was expected to produce approximately 220 tons per year of Ta_2O_5.

World Mine Production and Reserves: Reserves for Australia and Brazil were revised based on Government and industry information.

	Mine production		Reserves[8]
	2016	2017[e]	
United States	—	—	—
Australia	NA	NA	[9]78,000
Brazil	103	100	34,000
China	94	95	NA
Congo (Kinshasa)	370	370	NA
Ethiopia	63	60	NA
Nigeria	192	190	NA
Rwanda	350	390	NA
Other	45	65	NA
World total (rounded)	1,220	1,300	>110,000

World Resources: Identified resources of tantalum, most of which are in Australia, Brazil, and Canada, are considered adequate to meet projected needs. The United States has about 1,500 tons of tantalum resources in identified deposits, most of which are considered uneconomic at recent prices.

Substitutes: The following materials can be substituted for tantalum, but usually with less effectiveness: niobium in carbides; aluminum and ceramics in electronic capacitors; glass, niobium, platinum, 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 niobium and tantalum ores and concentrates, unwrought tantalum alloys and powder, tantalum waste and scrap, and other tantalum articles. Synthetic ore and concentrate was assumed to contain 32% Ta_2O_5. Niobium ore and concentrate was assumed to contain 32% Ta_2O_5. Tantalum ore and concentrate was assumed to contain 37% Ta_2O_5. Ta_2O_5 is about 81.9% Ta.

[2]Government stockpile inventory reported by DLA Strategic Materials is the basis for estimating Government stockpile releases.

[3]Defined as imports – exports + adjustments for Government and industry stock changes.

[4]Price is annual average price reported by CRU Group.

[5]Defined as imports – exports + adjustments for Government and industry stock changes.

[6]This category includes materials other than tantalum-containing material.

[7]See Appendix B for definitions.

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

[9]For Australia, Joint Ore Reserves Committee-compliant reserves were about 37,000 tons.

TELLURIUM

(Data in metric tons of tellurium content unless otherwise noted)

Domestic Production and Use: In 2017, one firm in Texas produced commercial-grade tellurium as a byproduct from domestic copper anode slimes. The primary producer and downstream producers further refined domestic and imported commercial-grade metal to produce tellurium dioxide, high-purity tellurium, and tellurium compounds for specialty applications. To avoid disclosing company proprietary data, U.S. tellurium production in 2017 was withheld.

Tellurium was used in the production of cadmium-telluride (CdTe) solar cells, which was the major end use for tellurium in the United States. Other 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 help control the depth of chill, and in malleable iron as a carbide stabilizer. It 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.

Global consumption estimates of tellurium by end use are: solar, 40%; thermoelectric production, 30%; metallurgy, 15%; rubber applications, 5%; and other, 10%.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, refinery	W	W	W	W	W
Imports for consumption	65	109	76	73	113
Exports	42	28	41	3	3
Consumption, apparent[1]	W	W	W	W	W
Price, dollars per kilogram[2]	116	113	80	36	36
Stocks, producer, refined, yearend	W	W	W	W	W
Net import reliance[3] as a percentage of apparent consumption	>50	>75	>75	>75	>75

Recycling: For traditional metallurgical and chemical uses, there was little or no old scrap from which to extract secondary tellurium because these uses of tellurium are highly dispersive or dissipative. A very small amount of tellurium was recovered from scrapped selenium-tellurium photoreceptors employed in older plain paper copiers in Europe. A plant in the United States recycled tellurium from CdTe solar cells; however, 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 (2013–16): Canada, 57%; China, 29%; Belgium, 7%; Philippines, 4%; and other, 3%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Tellurium	2804.50.0020	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: In 2017, domestic tellurium production was estimated to have remained essentially unchanged from that in 2016. The sole domestic producer shipped at least a portion of its anode slimes to Mexico for treatment and refining. World production of tellurium in 2017 was estimated to be about 420 tons. In 2017, the domestic average monthly price of tellurium generally increased in the first 7 months of the year, from around $30 per kilogram in January to $40 per kilogram in July. The average monthly price remained level at $40 per kilogram through October.

Domestic imports of tellurium were estimated to have increased by about 55% in 2017 from those of 2016, mostly as a result of a significant increase in imports from Canada and China. During the first 9 months of 2017, the United States imported 62 tons of tellurium from Canada and 36 tons from China, an increase from 35 tons and 6 tons, respectively, during the same period of the prior year.

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TELLURIUM

China is the leading producer of refined tellurium, recovering tellurium from anode slimes and industrial waste produced in copper, lead, zinc, nickel, and precious metals smelting processes and from mining tellurium in Dashuigou, in Shimian County, Sichuan Province.

Subsidies and tax credits for new solar construction that were aimed at encouraging domestic solar projects continued in the United States. The subsidies had been set to expire at the end of 2016, but legislation passed by Congress in December 2015 extended the 30% Solar Energy Credit until January 1, 2019. After this date, the credit begins to decrease incrementally, until it reaches 10% on January 1, 2022.

Investigations into the alleged fraudulent trading activities of the Fanya Metal Exchange Co. Ltd. (FME) in China continued in 2017. About 170 tons of tellurium reportedly were held in FME warehouses when the exchange closed, although this quantity has not been verified by the Government of China or a third party.

World Refinery Production and Reserves: The figures shown for reserves include only tellurium contained in copper reserves. These estimates assume that more than one-half of the tellurium contained in unrefined copper anodes is recoverable. A new source of data from China was identified for tellurium production and reserves data in 2017.

	Refinery production[e]		Reserves[4]
	2016	2017	
United States	W	W	3,500
Bulgaria	4	4	NA
Canada	18	20	800
China	280	280	6,600
Japan	33	38	—
Peru	—	—	3,600
Russia	35	35	NA
Sweden	39	40	670
Other countries[5]	NA	NA	16,000
World total (rounded)	[6]410	[6]420	31,000

World Resources: Data on tellurium resources were not available. More than 90% of tellurium has been produced from anode slimes collected from 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. 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.

The selenium-tellurium photoreceptors used in some plain paper photocopiers and laser printers have been replaced by organic photoreceptors in newer devices. Amorphous silicon and copper indium gallium selenide were the two principal competitors of CdTe in thin-film photovoltaic solar cells.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Defined as production + imports – exports + adjustments for industry stock changes.
[2]Average price published by Argus Media group–Argus Metals International for 99.95% tellurium, free on board, U.S. warehouses.
[3]Defined as imports – exports + adjustments for industry stock changes.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.
[5]In addition to the countries listed, Australia, Belgium, Chile, Colombia, Germany, India, Kazakhstan, Mexico, the Philippines, and Poland produce refined tellurium, but output was not reported and available information was inadequate to formulate reliable production and reserves estimates.
[6]Excludes U.S. production.

THALLIUM

(Data in kilograms unless otherwise noted)

Domestic Production and Use: Thallium has not been recovered in the United States since 1981. Consumption of thallium metal and thallium compounds was valued at $540,000. The primary end uses included the following: radioactive thallium-201 used for medical purposes in cardiovascular imaging; thallium as an activator (sodium iodide crystal doped with thallium) in gamma radiation detection equipment (scintillometer); thallium-barium-calcium-copper oxide high-temperature superconductor used in filters for wireless communications; thallium in lenses, prisms, and windows for infrared detection and transmission equipment; thallium-arsenic-selenium crystal filters for light diffraction in acousto-optical measuring devices; and thallium in mercury alloys for low-temperature measurements. Other uses include: as an additive in glass to increase its refractive index and density, a catalyst for organic compound synthesis, and a component in high-density liquids for gravity separation of minerals.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, refinery	—	—	—	—	—
Imports for consumption:					
Unwrought metal and metal powders	—	44	—	—	—
Waste and scrap	20	—	—	—	—
Other articles	1,470	53	334	193	75
Exports:					
Unwrought metal and metal powders	26	51	104	56	45
Waste and scrap	1,390	1,430	1,450	286	350
Other articles	56,400	1,050	1,070	973	1,500
Consumption, estimated[1]	1,490	97	334	193	75
Price, metal, dollars per kilogram[2]	6,990	7,200	7,400	7,400	7,200
Net import reliance[3] as a percentage of estimated consumption	100	100	100	100	100

Recycling: None.

Import Sources (2013–16): Russia, 89%; Germany, 9%; and other, 2%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Unwrought and powders	8112.51.0000	4.0% ad val.
Waste and scrap	8112.52.0000	Free.
Other	8112.59.0000	4.0% ad val.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: In 2017, the price for thallium metal declined slightly for the first time in 10 years. In 2017, China maintained its policy of eliminating toll-trading tax benefits on exports of thallium that began in 2006, thus contributing to the reduced supply to markets outside of China. In July 2010, China canceled a 5% value-added-tax rebate on exports of many minor metals, including fabricated thallium products.

Demand for thallium for use in cardiovascular-imaging applications has declined, owing to price increases and superior performance and availability of alternatives, such as the medical isotope technetium-99. A global shortage of technetium-99 from 2009 to 2011 had contributed to an increase in thallium consumption during that time period. Since 2011, consumption of thallium has declined significantly. Small quantities of thallium are used for research.

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THALLIUM

Two of the leading global markets for thallium were glass lenses, prisms, and windows for fiber optics, and optics for digital cameras. The majority of producers of these products were in China, Japan, and the Republic of Korea.

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 be absorbed into the human body by skin contact, ingestion, or inhalation of dust or fumes. The leading sources of thallium released into the environment are coal-burning powerplants and smelters of copper, lead, and zinc ores. The major sources of thallium in drinking water are ore-processing sites and discharges from electronics, drugs, and glass factories. Under its national primary drinking water regulations for public water supplies, the U.S. Environmental Protection Agency has set an enforceable Maximum Contaminant Level of 2 parts per billion of thallium in drinking water.

World Refinery Production and Reserves:[4] Thallium is produced commercially in only a few countries as a byproduct in the roasting of copper, lead, and zinc ores and is recovered from flue dust. Because most producers withhold thallium production data, global production data are limited. In 2017, global production of thallium was estimated to be less than 9,000 kilograms. China, Kazakhstan, and Russia were believed to be leading producers of primary thallium. Since 2005, substantial thallium-rich deposits have been identified in Brazil, China, Macedonia, and Russia.

World Resources: 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 the trace amounts found in copper, lead, zinc, and other sulfide ores. Quantitative estimates of reserves are 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 of thallium contained in zinc resources could be as much as 17 million kilograms; most are in Canada, Europe, and the United States. Global resources of coal contain an estimated 630 million kilograms of thallium.

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-99 can be used in cardiovascular-imaging applications instead of thallium.

Nonpoisonous substitutes, such as tungsten compounds, are being marketed as substitutes for thallium in high-density liquids for gravity separation of minerals.

[e]Estimated. — Zero.
[1]Estimated to be equal to imports.
[2]Estimated price of 99.99%-pure granules or rods in 100- to 250-gram or larger lots.
[3]Defined as imports – exports. Consumption and exports of unwrought thallium were from imported material or from a drawdown in unreported inventories.
[4]See Appendix C for resource and reserve definitions and information concerning data sources.

THORIUM

(Data in metric tons of thorium oxide (ThO_2) equivalent unless otherwise noted)

Domestic Production and Use: The world's primary source of thorium is the rare-earth and thorium phosphate mineral monazite. In 2017, monazite was not recovered domestically as a salable product. 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 2017 was about $730,000, compared with $284,000 in 2016.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, mine and refinery[1]	—	—	—	—	—
Imports for consumption:					
Thorium ore and concentrates (monazite), gross weight	—	—	—	16	—
Thorium ore and concentrates (monazite), ThO_2 content[e]	—	—	—	1	—
Thorium compounds (oxide, nitrate, etc.), gross weight	2.83	11.00	2.74	3.12	8.5
Thorium compounds (oxide, nitrate, etc.), ThO_2 content[e]	1.33	5.18	1.29	0.80	4.8
Exports:					
Thorium ore and concentrates (monazite), gross weight	—	—	—	—	—
Thorium compounds (oxide, nitrate, etc.), gross weight	1.01	[2]14.80	2.16	[2]63.9	[2]83.0
Thorium compounds (oxide, nitrate, etc.), ThO_2 content[e]	0.74	10.90	1.60	[3]3.00	[3]2.2
Consumption, apparent[4]	0.59	([5])	([5])	([5])	2.6
Value, thorium compounds, gross weight, dollars per kilogram, India[6]	65	65	63	65	73
Net import reliance[7] as a percentage of apparent consumption	100	100	100	100	100

Recycling: None.

Import Sources (2013–16): Monazite: Canada, 100%. Thorium compounds: India, 99% and the United Kingdom, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Thorium ores and concentrates (monazite)	2612.20.0000	Free.
Thorium compounds	2844.30.1000	5.5% ad val.

Depletion Allowance: Monazite, 22% on thorium content, and 14% on rare-earth and yttrium content (Domestic); 14% (Foreign).

Government Stockpile: None.

Events, Trends, and Issues: Domestic demand for thorium alloys, compounds, and metals was limited and believed to be largely for research purposes. Imports and existing stocks supplied essentially all thorium consumed in the United States in 2017. Globally, thorium's commercial uses included catalysts, high-temperature ceramics, research purposes, and welding electrodes.

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THORIUM

On the basis of data through September 2017, imports of unspecified thorium compounds were estimated to contain about 2.2 tons of thorium-oxide equivalent in 2017. The average value of imported thorium compounds decreased to $83 per kilogram compared with the 2016 average of $91 per kilogram (gross weight). India maintained its position as the primary source of imported thorium compounds in 2017. The unit value of imports from India increased to $73 per kilogram compared with $65 per kilogram in 2016. The unit value of imports from France and the United Kingdom were $123 and $673, respectively.

Exports of unspecified thorium compounds increased to 83 tons in 2017; however, 98% of the exports were reported to have a unit value less than $65 per metric ton and may have been misclassified. Owing to potentially misclassified material and variations in the type and purity of thorium compound, the unit value of exports varied widely by month and exporting district from a low of $2 per kilogram to a high of $9,500 per kilogram.

Globally, monazite was produced primarily for its rare-earth-element content, and only a small fraction of the byproduct thorium produced was consumed. India was the leading producer of monazite. Thorium consumption worldwide is relatively small compared with that of most other mineral commodities. In regard to international trade, China was the leading importer of monazite, and Brazil and Thailand were the leading exporters.

Several companies and countries were active in the pursuit of commercializing thorium as a fuel material for a new generation of nuclear reactors. Thorium-based nuclear research and development programs have been or are underway in Belgium, Brazil, Canada, China, Czechia, France, Germany, India, Israel, Japan, the Netherlands, Norway, Russia, the United Kingdom, and the United States.

The U.S. Environmental Protection Agency (EPA) was seeking public comments to proposed revisions to the EPA's “Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings.” The new standards would be applicable to byproduct materials produced by uranium in situ recovery.

World Refinery Production and Reserves:[8] Production and reserves are associated with the recovery of monazite in heavy-mineral-sand deposits. Without demand for the rare earths, monazite would probably not be recovered for its thorium content under current market demand conditions.

World Resources: The world’s leading thorium resources are found in placer, carbonatite, and vein-type deposits. Thorium is found in several minerals, including monazite, thorite, and thorianite. According to a report by the Organisation for Economic Co-operation and Development’s Nuclear Energy Agency and the International Atomic Energy Agency, worldwide thorium resources were estimated to total more than 6 million tons of thorium. Thorium resources are found throughout the world, most notably in Australia, Brazil, and India. India’s Department of Atomic Energy estimated 12 million tons of monazite was contained in heavy-mineral sands. India’s monazite was reported to have an average thorium oxide content of 9% to 10%. Geoscience Australia estimated Australia’s inferred resources to be about 0.5 million tons of thorium. Most of the identified thorium resources in Australia are within heavy-mineral-sand deposits. None of Australia’s thorium resources were classified as economically recoverable. Brazil’s thorium resources were estimated to be 0.6 million tons.

Substitutes: 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 and lanthanum can substitute for thorium in welding electrodes.

[e]Estimated. — Zero.
[1]All domestically consumed thorium was derived from imported materials.
[2]Includes material that may have been misclassified.
[3]Low unit-value exports were excluded from ThO_2 content estimate because they were believed to have been misclassified.
[4]Defined as imports – exports. Excludes ores and concentrates.
[5]The apparent consumption calculation yields a negative value from 2014 through 2016.
[6]Based on U.S. Census Bureau customs value.
[7]Defined as imports – exports; however, all exports were derived from imported materials, and net import reliance is assumed to be 100%.
[8]See Appendix C for resource and reserve definitions and information concerning data sources.

TIN

(Data in metric tons of tin content unless otherwise noted)

Domestic Production and Use: Tin has not been mined or smelted in the United States since 1993 and 1989, respectively. Twenty-five firms accounted for about 90% of the primary tin consumed domestically in 2017. The major uses for tin in the United States were chemicals, 21%; tinplate, 18%; solder, 17%; alloys, 10%; babbitt, bronze and brass, and tinning, 10%; and other, 24%. Based on the average Platts Metals Week New York dealer price for tin, the estimated value of imported refined tin was $596 million, and the estimated value of tin recovered from old scrap domestically was $220 million.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, secondary:					
Old scrap[e]	10,600	10,100	10,100	10,300	10,300
New scrap	2,150	1,900	1,120	1,050	2,000
Imports for consumption:					
Tin, refined	34,900	35,600	33,600	32,200	32,400
Tin, alloys, gross weight	1,390	1,570	2,720	1,910	1,520
Tin, waste and scrap, gross weight	63,700	49,700	32,700	27,200	55,200
Exports:					
Tin, refined	2,990	2,920	807	1,150	1,600
Tin, alloys, gross weight	2,870	2,790	2,540	1,040	940
Tin, waste and scrap, gross weight	5,020	7,480	2,530	4,570	3,460
Shipments from Government stockpile	—	—	—	—	—
Consumption, reported:					
Primary	25,700	24,200	23,900	25,900	23,300
Secondary	4,730	3,240	2,940	2,600	2,650
Consumption, apparent, refined[1]	42,900	42,400	42,700	42,100	40,900
Price, average, cents per pound:[2]					
New York dealer	1,041	1,023	839	838	950
Metals Week composite	1,352	NA	NA	NA	NA
London Metal Exchange, cash	1,012	994	729	815	920
Kuala Lumpur	1,012	993	NA	NA	NA
Stocks, consumer and dealer, yearend	6,520	6,970	7,090	6,510	6,580
Net import reliance[3] as a percentage of apparent consumption	75	76	76	76	75

Recycling: About 12,300 tons of tin from old and new scrap was estimated to have been recycled in 2017. Of this, about 10,300 tons was recovered from old scrap at 2 detinning plants and about 75 secondary nonferrous metal-processing plants, accounting for 25% of apparent consumption.

Import Sources (2013–16): Peru, 25%; Indonesia, 20%; Malaysia, 20%; Bolivia, 17%; and other, 18%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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: The Defense Logistics Agency Strategic Materials announced potential disposals of 804 tons of tin for fiscal year 2018. There were no disposals in fiscal year 2017.

Stockpile Status—9–30–17[4]

Material	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Tin	4,040	—	—

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TIN

Events, Trends, and Issues: Apparent consumption of tin in the United States was estimated to have decreased slightly in 2017 compared with consumption in 2016. Peru remained the primary supplier of tin to the United States, and the estimated amount of tin recycled in 2017 increased by 8% from that in 2016. Tin prices for the first 8 months in 2017 averaged about 937 and 902 cents per pound for the New York dealer price and London Metal Exchange price, respectively.

The monthly average New York dealer tin price increased significantly during 2016, beginning at 650 cents per pound in January and increasing to about 990 cents per pound in December, and has ranged between about 900 and 970 cents per pound during the first 10 months of 2017.

China's imports of tin in concentrate from Burma had reportedly increased, despite a decline in gross weight, as a result of improved processing equipment in the Man Maw mining area. In 2017, the average tin content of concentrate imported from Burma was estimated to be around 23%, compared with the 2016 average tin content of 13%. China also announced that in April 2017 it granted the first tolling license that would allow tin smelters to import tin concentrate and reexport metal without paying import or export taxes. In August 2017, the Government of Russia announced plans to develop two tin deposits in eastern Russia, and approved a tax exemption on tin produced in Russia until 2022. Russia's Ministry of Energy projected that these and other Government-instituted incentives could improve Russia's tin production tenfold.

World Mine Production and Reserves: Reserves for Australia, Burma, Congo (Kinshasa), and Peru were revised based on new information from Government and Industry sources.

	Mine production		Reserves[5]
	2016	2017[e]	
United States	—	—	—
Australia	6,640	7,000	[6]490,000
Bolivia	17,000	18,000	400,000
Brazil	25,000	25,500	700,000
Burma	54,000	50,000	113,000
China	92,000	100,000	1,100,000
Congo (Kinshasa)	5,500	5,800	150,000
Indonesia	52,000	50,000	800,000
Laos	1,300	1,000	NA
Malaysia	4,000	4,000	250,000
Nigeria	2,290	2,400	NA
Peru	18,800	18,000	105,000
Russia	1,100	1,000	350,000
Rwanda	2,200	1,800	NA
Thailand	100	70	170,000
Vietnam	5,500	5,400	11,000
Other countries	242	200	180,000
World total (rounded)	288,000	290,000	4,800,000

World Resources: Identified resources of tin in the United States, primarily in Alaska, were insignificant compared with those of 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 content 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 production (old scrap) + imports – exports + adjustments for Government and industry stock changes, excluding imports and exports of waste and scrap.

[2]Source: Platts Metals Week.

[3]Defined as imports – exports + adjustments for Government and industry stock changes, excluding imports and exports of waste and scrap.

[4]See Appendix B for definitions.

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

[6]For Australia, Joint Ore Reserves Committee-compliant reserves were about 260,000 tons.

TITANIUM AND TITANIUM DIOXIDE[1]

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Titanium sponge metal was produced by two operations in Nevada and 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, used the Armstrong method to produce high-purity titanium for use in electronics. The operations in Nevada, with an estimated capacity of 12,600 tons per year, used the Kroll method, the dominant process of titanium sponge production for use in aerospace, industrial, and all other applications. A third facility, in Rowley, UT, which produced titanium sponge using the Kroll method, was idled and placed on care-and-maintenance status in 2016 owing to low titanium sponge prices.

In 2017, an estimated 80% of titanium metal was used in aerospace applications; the remaining 20% was used in armor, chemical processing, marine hardware, medical implants, power generation, and consumer and other applications. Assuming an average purchase price of $8.60 per kilogram, the value of sponge metal consumed was about $318 million.

In 2017, titanium dioxide (TiO_2) pigment production, by four companies operating five facilities in four States, was valued at about $3.0 billion. The estimated end-use distribution of TiO_2 pigment consumption was paints (including lacquers and varnishes), 68%; plastics, 25%; paper, 3%; and other, 4%. Other uses of TiO_2 included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Titanium sponge metal:					
Production	W	W	W	W	W
Imports for consumption	19,900	17,700	20,700	16,200	23,000
Exports	1,860	2,590	1,700	724	3,500
Consumption, reported	26,500	26,400	31,200	34,100	37,000
Price, dollars per kilogram, yearend	11.00	10.00	9.40	9.50	8.60
Stocks, industry, yearend[e]	25,200	22,900	25,000	25,100	20,000
Employment, number[e]	300	300	300	150	150
Net import reliance[2] as a percentage of reported consumption	68	57	61	45	53
Titanium dioxide pigment:					
Production	1,280,000	1,260,000	1,220,000	1,240,000	1,260,000
Imports for consumption	213,000	224,000	221,000	247,000	182,000
Exports	671,000	685,000	649,000	651,000	622,000
Consumption, apparent[3]	826,000	802,000	792,000	840,000	820,000
Producer price index (1982=100), yearend[4]	236	224	176	175	170
Employment, number[e]	3,400	3,400	3,110	3,110	3,110
Net import reliance[2] as a percentage of apparent consumption	E	E	E	E	E

Recycling: About 69,600 tons of titanium scrap metal was consumed in 2017—58,000 tons by the titanium industry, 9,800 tons by the steel industry, 530 tons by the superalloy industry, and 1,300 tons by other industries.

Import Sources (2013–16): Sponge metal: Japan, 78%; China, 8%; Kazakhstan, 6%; Ukraine, 6%; and other, 2%. Titanium dioxide pigment: Canada, 31%; China, 24%; Germany, 10%; and other, 35%.

Tariff: Item	**Number**	**Normal Trade Relations 12–31–17**
Titanium oxides (unfinished TiO_2 pigments)	2823.00.0000	5.5% ad val.
TiO_2 pigments, 80% or more TiO_2	3206.11.0000	6.0% ad val.
TiO_2 pigments, other	3206.19.0000	6.0% ad val.
Ferrotitanium and ferrosilicon titanium	7202.91.0000	3.7% ad val.
Unwrought titanium metal	8108.20.0010	15.0% ad val.
Titanium waste and scrap metal	8108.30.0000	Free.
Other titanium metal articles	8108.90.3000	5.5% ad val.
Wrought titanium metal	8108.90.6000	15.0% ad val.

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TITANIUM AND TITANIUM DIOXIDE

Depletion Allowance: Not applicable.

Government Stockpile: None.

Events, Trends, and Issues: Domestic consumption of titanium sponge in 2017 was estimated to have increased by about 9% from that of 2016 owing to increased demand by the aerospace industry. Additive manufacturing (3D printing) for aerospace applications continued to progress as the two major global aerospace manufacturers took deliveries of titanium structural components made using 3D-printing techniques.

Domestic production of TiO_2 pigment in 2017 was estimated to be about 1.26 million tons, a slight increase from that of 2016. In February, one of the existing domestic producers announced a merger to acquire the mineral sands and pigment operations of another company, which included TiO_2 pigment production operations in Ashtabula, OH. The acquisition, expected to be completed by the end of the first quarter of 2018, would result in a combined company with a capacity of 858 million tons per year and would be the largest global producer of TiO_2 pigments. In Pori, Finland, a 130,000-ton-per-year pigment plant experienced fire damage and at yearend 2017 was not operational.

World Sponge Metal Production and Sponge and Pigment Capacity:

	Sponge production		Capacity 2017[5]	
	2016	2017[e]	Sponge	Pigment
United States	W	W	13,100	1,360,000
Australia	—	—	—	260,000
Belgium	—	—	—	87,000
Canada	—	—	—	102,000
China[e]	60,000	60,000	110,000	2,940,000
France	—	—	—	32,000
Germany	—	—	—	456,000
India	500	500	500	108,000
Italy	—	—	—	80,000
Japan[e]	54,000	48,000	68,800	314,000
Kazakhstan[e]	9,000	9,000	26,000	1,000
Mexico	—	—	—	300,000
Russia[e]	38,000	40,000	46,500	20,000
Ukraine[e]	8,000	8,000	12,000	120,000
United Kingdom	—	—	—	315,000
Other countries	—	—	—	806,000
World total (rounded)	[6]170,000	[6]170,000	277,000	7,300,000

World Resources: Resources and reserves of titanium minerals are discussed in the "Titanium Mineral Concentrates" chapter of this publication.

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 titanium dioxide as a white pigment.

[e]Estimated. E Net exporter. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]See also Titanium Mineral Concentrates.
[2]Defined as imports – exports.
[3]Defined as production + imports – exports.
[4]U.S. Department of Labor, Bureau of Labor Statistics.
[5]Yearend operating capacity.
[6]Excludes U.S. production.

TITANIUM MINERAL CONCENTRATES[1]

(Data in thousand metric tons of TiO_2 content unless otherwise noted)

Domestic Production and Use: In 2017, two firms recovered ilmenite and rutile concentrates from surface-mining operations in Florida and Georgia and a third company began processing existing mineral sands tailings in Florida. Based on reported data through November 2017, the estimated value of titanium mineral concentrates consumed in the United States in 2017 was $561 million. Zircon was a coproduct of mining from ilmenite and rutile deposits. About 90% of titanium mineral concentrates were consumed by domestic titanium dioxide (TiO_2) pigment producers. The remaining 10% was used in welding-rod coatings and for manufacturing carbides, chemicals, and metal.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production[2]	200	100	200	100	100
Imports for consumption	1,190	1,110	1,100	1,020	1,050
Exports, all forms[e]	7	1	2	5	6
Consumption, apparent[3]	1,380	1,210	1,300	1,120	1,140
Price, dollars per metric ton:					
Ilmenite, bulk, minimum 54% TiO_2, f.o.b. Australia[4]	265	155	110	105	170
Rutile, bulk, minimum 95% TiO_2, f.o.b. Australia[4]	1,250	950	840	740	740
Slag, 80%–95% TiO_2[5]	538–777	720–762	727–753	650–685	661–703
Employment, mine and mill, number[e]	195	144	214	186	296
Net import reliance[6] as a percentage of apparent consumption	86	92	85	91	91

Recycling: None.

Import Sources (2013–16): South Africa, 37%; Australia, 29%; Canada, 14%; Mozambique, 11%; and other, 9%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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 tied to production of TiO_2 pigments that are primarily used in paint, paper, and plastics. Domestic apparent consumption of titanium mineral concentrates in 2017 was estimated to have increased slightly from that of 2016.

Domestic mining and production of titanium mineral concentrates took place at one mine near Starke, FL, and one mine near Nahunta, GA. Prices for rutile remained constant throughout 2017, but ilmenite prices increased by over 60% at midyear. A company was conducting a feasibility study of the Dundas ilmenite project on the northwest coast of Greenland. Large-scale production was expected to begin in 2019 contingent upon obtaining customer offtake agreements. A major producer of titanium minerals was restarting its Jacinth-Ambrosia Mine in Western Australia and was further developing its operations in Sierra Leone in order to increase its production of natural rutile. Other projects were being developed in Australia, Mozambique, and Tanzania.

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TITANIUM MINERAL CONCENTRATES

World Mine Production and Reserves: Rutile reserves for Mozambique and Sierra Leone were added based on reported company data. Reserves for Australia were revised based on new Government reports.

	Mine production[e] 2016	Mine production[e] 2017	Reserves[7]
Ilmenite:			
United States[2]	[8]100	[8]100	[8]2,000
Australia	780	900	[9]250,000
Brazil	48	50	43,000
Canada[10]	595	475	31,000
China	840	800	220,000
India	180	200	85,000
Kenya	280	375	54,000
Madagascar	92	140	40,000
Mozambique	540	550	14,000
Norway	260	260	37,000
Senegal	250	300	NA
South Africa[10]	1,020	1,300	63,000
Ukraine	210	350	5,900
Vietnam	240	300	1,600
Other countries	71	90	26,000
World total (ilmenite, rounded)	[8]5,500	[8]6,200	[8]870,000
Rutile:			
United States	([8])	([8])	([8])
Australia	380	450	[9]29,000
India	19	20	7,400
Kenya	84	80	13,000
Mozambique	7	7	880
Senegal	9	10	NA
Sierra Leone	130	160	490
South Africa	67	65	8,300
Ukraine	95	90	2,500
Other countries	8	15	400
World total (rutile, rounded)	[8]800	[8]900	[8]62,000
World total (ilmenite and rutile, rounded)	6,300	7,100	930,000

World Resources: Ilmenite accounts for about 89% 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 Titanium and Titanium Dioxide.
[2]Rounded to the nearest 100,000 tons to avoid disclosing company proprietary data.
[3]Defined as production + imports – exports.
[4]Source: Industrial Minerals; yearend average of high-low price.
[5]Landed duty-paid value based on U.S. imports for consumption. Data series revised to reflect annual average price range of significant importing countries.
[6]Defined as imports – exports.
[7]See Appendix C for resource and reserve definitions and information concerning data sources.
[8]U.S. rutile production and reserves data are included with ilmenite.
[9]For Australia, Joint Ore Reserves Committee-compliant reserves for ilmenite and rutile were about 57 million and 7 million tons, respectively.
[10]Mine production is primarily used to produce titaniferous slag.

TUNGSTEN

(Data in metric tons of tungsten content unless otherwise noted)

Domestic Production and Use: There was no known domestic commercial production of tungsten concentrates during 2016 or 2017. Approximately seven companies in the United States processed tungsten concentrates, ammonium paratungstate, tungsten oxide, and (or) scrap to make tungsten metal powder, tungsten carbide powder, and (or) tungsten chemicals. About 55% of the tungsten used 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 remaining tungsten 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. The estimated value of apparent consumption in 2017 was approximately $500 million.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production:					
Mine	NA	NA	NA	—	—
Secondary	8,600	W	W	W	W
Imports for consumption:					
Concentrate	3,690	4,080	3,970	3,580	3,900
Other forms	8,460	8,820	6,270	6,300	10,000
Exports:					
Concentrate	1,050	1,230	398	183	700
Other forms	6,660	5,490	3,360	3,200	3,100
Government stockpile shipments:					
Concentrate	2,100	282	—	—	1,400
Other forms	—	([1])	—	—	—
Consumption:					
Reported, concentrate	W	W	W	W	W
Apparent, all forms[2]	14,600	W	W	W	W
Price, concentrate, dollars per mtu WO_3,[3] average, U.S. spot market, Platts Metals Week	358	348	302	148	245
Stocks, industry, yearend, concentrate and other forms	W	W	W	W	W
Net import reliance[4] as a percentage of apparent consumption	41	>25	>25	>25	>50

Recycling: The estimated quantity of tungsten consumed from secondary sources by processors and end users in 2017 was withheld to avoid disclosing company proprietary data.

Import Sources (2013–16): Tungsten contained in ores and concentrates, intermediate and primary products, wrought and unwrought tungsten, and waste and scrap: China, 34%; Canada, 10%; Bolivia, 9%; Germany, 8%; and other, 39%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Ores	2611.00.3000	Free.
Concentrates	2611.00.6000	37.5¢/kg tungsten content.
Tungsten oxides	2825.90.3000	5.5% ad val.
Ammonium tungstates	2841.80.0010	5.5% ad val.
Tungsten carbides	2849.90.3000	5.5% ad val.
Ferrotungsten	7202.80.0000	5.6% ad val.
Tungsten powders	8101.10.0000	7.0% ad val.
Tungsten waste and scrap	8101.97.0000	2.8% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9–30–17[5]

Material	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Metal powder	125	35	—
Ores and concentrates	10,400	1,360	1,240
Tungsten alloys, gross weight	1	—	—

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TUNGSTEN

Events, Trends, and Issues: World tungsten supply was dominated by production in China and exports from China. China's Government regulated its tungsten industry by limiting the number of mining and export licenses, imposing quotas on concentrate production, and placing constraints on mining and processing. During 2016 and 2017, China's efforts to enforce production quotas, reduce illegal mining, and improve environmental conditions resulted in limited availability of tungsten concentrates in China. Environmental inspections also reduced China's production of downstream materials such as ammonium paratungstate. Total mine production outside China was expected to be slightly higher than that of 2016. The anticipated combined decrease in production from Mongolia, Rwanda, Spain, and elsewhere was less than the combined increase in production expected from the United Kingdom, where a newly started mine was ramping up production, and Vietnam, where the largest mine outside China improved its productivity.

China was the world's leading tungsten consumer. During the first 6 to 9 months of 2017, China's consumption of tungsten concentrates and its production and exports of downstream tungsten materials were higher than those of 2016, indicating an increase in global tungsten consumption. Prices of tungsten concentrates and downstream tungsten materials continued the upward trends that began in late 2015 or early 2016.

World Mine Production and Reserves: Reserves for China, Mongolia, Portugal, Russia, Spain, the United Kingdom, and "Other countries" were revised based on company or Government reports.

	Mine production		Reserves[6]
	2016	2017[e]	
United States	—	—	NA
Austria	954	950	10,000
Bolivia	1,110	1,100	NA
China	72,000	79,000	1,800,000
Mongolia	753	150	63,000
Portugal	549	680	3,100
Russia	3,100	3,100	160,000
Rwanda	820	650	NA
Spain	650	570	54,000
United Kingdom	736	1,100	43,000
Vietnam	6,500	7,200	95,000
Other countries	880	860	950,000
World total (rounded)	88,100	95,000	3,200,000

World Resources: World tungsten resources are geographically widespread. China ranks first in the world in terms of tungsten resources and reserves and has some of the largest deposits. Canada, Kazakhstan, Russia, and the United States also have significant tungsten resources.

Substitutes: Potential substitutes for cemented tungsten carbides include cemented carbides based on molybdenum carbide and titanium carbide, ceramics, ceramic-metallic composites (cermets), and tool steels. Potential substitutes for other applications are as follows: molybdenum for certain tungsten mill products; molybdenum steels for tungsten steels; 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]Less than ½ unit.
[2]Defined as secondary production + net import reliance.
[3]A metric ton unit (mtu) of tungsten trioxide (WO_3) contains 7.93 kilograms of tungsten.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix B for definitions.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.

VANADIUM

(Data in metric tons of vanadium content unless otherwise noted)

Domestic Production and Use: In 2017, secondary vanadium production continued primarily in Arkansas, Delaware, Ohio, Pennsylvania, and Texas, where processed waste materials (petroleum residues, spent catalysts, utility ash, and vanadium-bearing pig iron slag) were used to produce ferrovanadium, vanadium pentoxide, vanadium metal, and vanadium-bearing chemicals or specialty alloys. In 2009–13, small quantities of vanadium were produced as a byproduct from the mining of uraniferous sandstones on the Colorado Plateau. All byproduct vanadium production has been suspended since 2014. Metallurgical use, primarily as an alloying agent for iron and steel, accounted for about 94% of domestic vanadium consumption in 2017. Of the other uses for vanadium, the major nonmetallurgical use was in catalysts for the production of maleic anhydride and sulfuric acid.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production, mine, mill	591	—	—	—	—
Imports for consumption:					
Ferrovanadium	3,710	3,230	1,980	1,590	3,000
Vanadium pentoxide, anhydride	2,040	3,410	2,870	2,460	2,700
Oxides and hydroxides, other	205	104	94	660	150
Aluminum-vanadium master alloys (gross weight)	169	431	204	235	480
Ash and residues	4,190	6,160	8,210	5,030	4,800
Sulfates	30	19	13	12	7
Vanadates	276	197	173	313	330
Vanadium metal[1] (gross weight)	35	161	182	45	46
Exports:					
Ferrovanadium	299	253	122	400	270
Vanadium pentoxide, anhydride	90	201	356	5	77
Oxides and hydroxides, other	407	350	100	81	120
Aluminum-vanadium master alloys (gross weight)	347	443	229	95	230
Ash and residues	4,000	2,300	370	1,100	2,700
Vanadium metal[1] (gross weight)	58	32	5	19	94
Consumption:					
Apparent[2]	6,130	10,100	12,500	8,600	7,900
Reported	3,980	4,070	3,930	3,830	3,000
Price, average, dollars per pound vanadium pentoxide	6.04	5.61	4.16	3.38	5.20
Stocks, yearend[3]	166	170	166	168	170
Net import reliance[4] as a percentage of apparent consumption	90	100	100	100	100

Recycling: The quantity of vanadium recycled from spent chemical process catalysts was significant and may compose as much as 40% of total vanadium catalysts. Some tool steel scrap was recycled primarily for its vanadium content, but this only accounted for a small percentage of total vanadium used.

Import Sources (2013–16): Ferrovanadium: Czechia, 32%; Austria, 22%; Canada, 19%; Republic of Korea, 18%; and other, 9%. Vanadium pentoxide: South Africa, 48%; Russia, 26%; China, 10%; Switzerland, 9%, and other, 7%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–17**
Vanadium bearing ash and residues	2620.40.0030	Free.
Vanadium bearing ash and residues, other	2620.99.1000	Free.
Chemical compounds:		
Vanadium pentoxide anhydride	2825.30.0010	5.5% ad val.
Vanadium oxides and hydroxides, other	2825.30.0050	5.5% ad val.
Vanadium sulfates	2833.29.3000	5.5% ad val.
Vanadates	2841.90.1000	5.5% ad val.
Ferrovanadium	7202.92.0000	4.2% ad val.
Vanadium metal	8112.92.7000	2.0% ad val.
Vanadium and articles thereof[5]	8112.99.2000	2.0% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

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VANADIUM

Events, Trends, and Issues: U.S. apparent consumption of vanadium in 2017 decreased by 8% from that of 2016. Among the major uses for vanadium, production of carbon, full-alloy, and high-strength low-alloy steels accounted for 16%, 44%, and 36%, respectively, of domestic consumption. U.S. imports for consumption of vanadium in 2017 increased by 10% from those of the previous year. The main increase was in imports of ferrovanadium. U.S. exports more than doubled from those of the previous year. The main increase was in exports of vanadium-bearing ash and residues.

An iron and vanadium mine in South Africa remained closed and left South Africa with only two major producers of vanadium. A company in Austria, which also received raw material from the mine in South Africa, was expected to acquire feedstock from an alternative source. The vanadium products produced at this company included aluminum-vanadium, ferrovanadium, vanadium chemicals, and vanadium oxides.

Few new vanadium operations have been commissioned in recent years, with the exception of a producer in Brazil. The producer achieved full rampup of capacity in 2017, creating new material for the market.

Research in vanadium redox battery (VRB) technology continued as VRB system installations developed worldwide. Installations were concentrated in China, Japan, North America, and Europe.

Vanadium pentoxide prices slowly increased throughout 2017. In September 2017, vanadium pentoxide prices were $5.05 per pound. Vanadium pentoxide prices in 2017 averaged $5.20 compared with $3.38 per pound in 2016. Ferrovanadium prices however, increased more substantially. In September 2017, ferrovanadium prices averaged $21.10 per pound. Prices had not been this high since November 2008. Increased environmental inspections in China have continued to temporarily, or in some cases permanently, close some vanadium producers. As availability of vanadium pentoxide has decreased, prices have increased and many major ferrovanadium producers in China have been forced to reduce production, causing ferrovanadium prices to increase.

World Mine Production and Reserves:

	Mine production		Reserves[6]
	2016	2017[e]	(thousand metric tons)
United States	—	—	45
Australia	—	—	[7]2,100
Brazil	8,000	8,400	NA
China	45,000	43,000	9,000
Russia	16,000	16,000	5,000
South Africa	10,000	13,000	3,500
World total (rounded)	79,000	80,000	20,000

World Resources: 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. Although domestic resources and secondary recovery are adequate to supply a large portion of domestic needs, all of U.S. demand is currently met by foreign sources.

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. NA Not available. — Zero.
[1]Vanadium metal includes waste and scrap.
[2]Defined as production + imports – exports + adjustments for industry stock changes.
[3]Includes chlorides, ferrovanadium, vanadates, vanadium-aluminum alloy, other vanadium alloys, vanadium metal, vanadium pentoxide, and other specialty chemicals.
[4]Defined as imports – exports + adjustments for industry stock changes.
[5]Aluminum-vanadium master alloy consisting of 35% aluminum and 64.5% vanadium.
[6]See Appendix C for resource and reserve definitions and information concerning data sources.
[7]For Australia, Joint Ore Reserves Committee-compliant reserves were about 1.3 million tons.

VERMICULITE

(Data in thousand metric tons unless otherwise noted)

Domestic Production and Use: Two companies with mining and processing facilities in South Carolina and Virginia produced vermiculite concentrate and reported production of approximately 100,000 tons. Flakes of raw vermiculite concentrate are micaceous in appearance and contain interlayer water in their structure. When the flakes are heated rapidly at a temperature above 870 °C, the water flashes into steam, and the flakes expand into accordionlike particles. This process is called exfoliation, or expansion, and the resulting lightweight material is chemically inert, fire resistant, and odorless. Most of the vermiculite concentrate produced in the United States was shipped to 17 exfoliating plants in 11 States. The end uses for exfoliated vermiculite were estimated to be agriculture and horticulture, 43%; lightweight concrete aggregates (including cement premixes, concrete, and plaster), 19%; insulation, 8%; and other, 30%.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production[e]	100	100	100	100	100
Imports for consumption[e, 2]	36	43	21	46	45
Exports[e]	2	3	2	2	2
Consumption, apparent, concentrate[3]	130	140	120	140	140
Consumption, reported, exfoliated	64	63	65	68	65
Price, range of value, concentrate, dollars per ton, ex-plant	145–525	145–565	140–575	140–575	140–575
Employment, number[e]	65	68	69	69	70
Net import reliance[4] as a percentage of apparent consumption	25	30	20	30	30

Recycling: Insignificant.

Import Sources (2013–16): Brazil, 42%; South Africa, 34%; China, 20%; Zimbabwe, 3%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
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: U.S. exports and imports of vermiculite are not collected as a separate category by the U.S. Census Bureau. However, according to an independent industry trade information source, United States imports, excluding any material from Canada and Mexico, were estimated to be about 45,000 tons in 2017, slightly lower than those of 2016. Coarse-grade vermiculite remained in short supply; however prices were unchanged in 2017; most imports in 2017 came from China, South Africa, and Zimbabwe.

A company based in Australia produced vermiculite concentrate at the Namekara vermiculite mine in Uganda. The deposit is considered to be one of the world's largest vermiculite deposits that contain significant portions of medium- and coarse-grade material. A drilling program continued to better define the resource. The company confirmed sales of vermiculite concentrate into southern Africa, and its first sale to North America. Its operating subsidiary entered into 12-month contracts to supply vermiculite concentrate to customers in Japan, the United Kingdom, and other countries in Europe. The 30,000-ton-per-year mine capacity may increase to 80,000 tons per year during the next several years. The Namekara deposit has sufficient resources for more than 50 years of production at the higher rate.

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VERMICULITE

A company in Turkey continued development and began production at the country's first vermiculite mine at the Karakoc deposit in Sivas in central Turkey. A company based in France, which was a partner in the project, was arranging the vermiculite sales. Although production continued to ramp up, first year production was expected to be about 5,000 tons.

Companies in China with significant vermiculite resources also were ramping up production, although processing operations were somewhat constrained by increased enforcement of environmental regulations. A company based in France, in cooperation with the Government of Zimbabwe and local governments, intermittently produced vermiculite concentrate, including a significant portion of coarse-grade vermiculite, at the Shawa deposit in Zimbabwe. The mine had an expected life of more than 30 years. The deposit also is considered to be one of the world's largest vermiculite deposits that contain significant portions of medium- and coarse-grade material. A company in Brazil expanded production capacity at its vermiculite mine in central Brazil and was developing another deposit near Brasilia. The goal was to bring the company's total production capacity to 200,000 tons per year.

World Mine Production and Reserves:

	Mine production		Reserves[5]
	2016	2017[e]	
United States[e]	[1]100	[1]100	25,000
Brazil	55	50	6,300
Bulgaria	10	10	NA
China	NA	NA	NA
India	13	10	1,700
Russia	20	20	NA
South Africa	166	170	14,000
Uganda	3	20	NA
Zimbabwe	35	40	NA
Other countries	2	20	NA
World total	404	440	NA

World Resources: Vermiculite occurrences in Colorado, Nevada, North Carolina, Texas, and Wyoming contain estimated resources of 2 million to 3 million tons. Significant deposits have been reported in Australia, China, Russia, Uganda, and some other countries, but reserves 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 substitutes in these applications are 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. Data are rounded to one significant digit to avoid disclosing company proprietary data.

[2]Excludes Canada and Mexico.

[3]Defined as concentrate sold or used by producers + imports – exports.

[4]Defined as imports – exports.

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

WOLLASTONITE

(Data in metric tons unless otherwise noted)

Domestic Production and Use: Wollastonite was mined by two companies in New York during 2017. 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 of 2016. 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, but New York is the only State where long-term continuous mining has taken place.

The U.S. Geological Survey does not collect consumption statistics for wollastonite, but consumption was estimated to have been about the same in 2017 as compared with the previous year. 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 thought to be a net exporter of wollastonite in 2017. Comprehensive trade data were not available for wollastonite because it is imported and exported under a generic Harmonized Tariff Schedule code that includes multiple mineral commodities. Ex-works prices for domestic wollastonite were reported in trade literature to range from approximately $210 to $445 per ton, and free-on-board prices for wollastonite from China, which tends to be minimally refined, ranged from $80 to $105 per ton. Products with finer grain sizes and acicular (highly elongated) particles sold for higher prices. Surface treatment, when necessary, also increased the selling price. Approximately 94 people were employed at wollastonite mines and mills in 2017 (excluding office workers).

Recycling: None.

Import Sources (2013–16): Comprehensive trade data were not available, but wollastonite was primarily imported from China, Finland, India, and Mexico.

Tariff:

Item	Number	Normal Trade Relations 12–31–17
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: U.S. housing starts in 2017 were 9% higher through August compared with that in the same time period during 2016, suggesting that sales of wollastonite to domestic construction-related markets, such as adhesives, caulks, cement board, ceramic tile, paints, stucco, and wallboard, might have increased. Use in other major markets for wollastonite increased as well: plastics increased slightly and primary iron and steel products rose by 4%. Production of motor vehicles and parts, which contain wollastonite in friction products and plastic and rubber components, and rubber, remained the same.

Globally, ceramics, polymers (such as plastics and rubber), and paint accounted for most wollastonite sales. Lesser global uses for wollastonite included miscellaneous construction products, friction materials, metallurgical applications, and paper. In Western Europe and Asia, demand for wollastonite likely remained relatively unchanged owing to minimal growth in its use in construction and manufacturing.

The leading U.S. producer of wollastonite continued to pursue a potential new mine within the Adirondack Forest Preserve of New York. This land became available for development as part of a land swap transaction approved by the State of New York in 2013. According to a company representative, the project was still in the development stage as of late **2017**. Previous estimates suggest that the 81-hectare property contains 1.2 million to 1.5 million tons of wollastonite reserves, sufficient to extend mining operations in the area by an additional 10 years.

World Mine Production and Reserves: United States production of wollastonite ranks third globally. Many countries either do not publish wollastonite production or production is reported with a 2- to 3-year lag time.

	Mine production[e]	
	2016	2017
United States	W	W
Canada	11,000	7,000
China	500,000	500,000
Finland	10,000	10,000
India	180,000	170,000
Mexico	64,000	79,000
Other countries	6,000	6,000
World total (rounded)	[2]770,000	[2]770,000

Reserves[1]

World reserves of wollastonite exceed 100 million tons. Many deposits, however, have not been surveyed, precluding accurate reserves estimates.

World Resources: 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 it 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]See Appendix C for resource and reserve definitions and information concerning data sources.
[2]Excludes U.S. production.

YTTRIUM[1]

[Data in metric tons of yttrium oxide (Y_2O_3) equivalent content unless otherwise noted]

Domestic Production and Use: Rare earths were not mined domestically in 2017. Bastnaesite, a rare-earth fluorocarbonate mineral, was previously mined as a primary product at the Mountain Pass Mine in California, which was put on care and maintenance 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.

The leading end uses of yttrium were in ceramics, 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 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. 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. Yttrium was used in phosphor compounds for flat-panel displays and various lighting applications.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, mine[2]	NA	NA	NA	—	—
Imports for consumption:					
Yttrium, alloys, compounds, and metal[e, 3]	200	200	360	340	380
Exports, compounds[e, 4]	NA	NA	39	2	2
Consumption, estimated[5]	200	200	300	300	300
Price,[e] dollars:					
Yttrium oxide, per kilogram, minimum 99.999 purity[6]	23–27	15–17	7–8	4	3-4
Yttrium metal, per kilogram, minimum 99.9% purity[6]	60–70	55–65	45–51	34–36	34-35
Net import reliance[2, 7] as a percentage of apparent consumption	>95	>95	>95	100	100

Recycling: Insignificant.

Import Sources (2013–16):[8] Yttrium compounds: China, 71%; Estonia, 12%; Japan, 6%; Germany, 3%; and other, 8%. Nearly all imports of yttrium metal and compounds are derived from mineral concentrates produced in China. Import sources do not include yttrium contained in value-added intermediates and finished products.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Rare-earth metals, unspecified, whether or not intermixed or interalloyed	2805.30.0090	5.0% ad val.
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	2846.90.8000	3.7% ad val.

Depletion Allowance: Monazite, thorium content, 22% (Domestic), 14% (Foreign); yttrium, rare-earth content, 14% (Domestic and foreign); and xenotime, 14% (Domestic and foreign).

Government Stockpile: In fiscal year (FY) 2017, the Defense Logistics Agency acquired 15.7 tons of yttrium oxide. The FY 2018 National Defense Stockpile Annual Materials Plan included a maximum acquisition of 10 tons of yttrium oxide.

Stockpile Status—9–30–17[9]

Material	Inventory	Disposal Plan FY 2017	Disposals FY 2017
Yttrium oxide	24.5	—	—

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YTTRIUM

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 Provinces. Processing was primarily at facilities in Guangdong, Jiangsu, and Jiangxi Provinces.

In 2017, global consumption of yttrium oxide was estimated to be 5,000 to 7,000 tons. 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.

Although global consumption increased, owing to an abundance of supply, prices for yttrium metal and oxide remained nearly unchanged in 2017. According to industry reports, increasing popularity of light-emitting-diode lighting over traditional fluorescent lighting has reduced the consumption of yttrium-based phosphors.

Using China's export codes and preliminary export statistics, yttrium oxide (2846.90.11) exports increased in 2017. During the first 8 months of 2017, China exported 1,460 tons of yttrium oxide, primarily to Japan (50%), Italy (18%), and the United States (12%). China's other year-to-date exports of yttrium included 0.6 tons of yttrium fluoride (2846.90.36), 37 tons of unspecified yttrium compounds (2846.90.96), and 18 tons of yttrium metal (2805.30.17). No exports of yttrium carbonate (2846.90.46) and yttrium chloride (2846.90.26) were reported. China continued efforts to manage its rare-earth industry through industry consolidations, crackdowns on illegal production, and stockpiling.

World Mine Production and Reserves:[10] World production of yttrium oxide was almost entirely from China and was estimated to be less than the available supply of 5,000 to 7,000 tons. Programs to stem the undocumented production of rare earths in China were ongoing. Reserves of yttrium are associated with those of rare earths. Global reserves of yttrium oxide were estimated to be more than 500,000 tons. The leading countries for these reserves included Australia, Brazil, China, India, and the United States. Although reserves may be sufficient to satisfy near-term demand at current rates of production, economics, environmental issues, and permitting and trade restrictions could affect the mining or availability of many of the rare-earth elements, including yttrium.

World Resources: 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, nonplacer 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 substitution by other elements. As a stabilizer in zirconia ceramics, yttrium oxide may be substituted with calcium oxide or magnesium oxide, but the substitutes generally impart lower toughness.

[e]Estimated. NA Not available. — Zero.
[1]See also Rare Earths; trade data for yttrium are included in the data shown for rare earths.
[2]Includes yttrium contained in rare-earth ores and mineral concentrates.
[3]Estimated from Trade Mining LLC shipping records.
[4]Estimated from Harmonized System-based Schedule B code: 2846.90.2015.
[5]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 Metals International, London, United Kingdom.
[7]Defined as imports – exports. From 2013–15, insufficient data were available to determine exports and were excluded from the calculation.
[8]Includes estimated yttrium oxide equivalent from the following Harmonized Tariff Schedule codes: 2846.90.2015, 2846.90.2082, 2846.90.4000, 2846.90.8050, and 2846.90.8060.
[9]See Appendix B for definitions.
[10]See Appendix C for resource and reserve definitions and information concerning data sources.

ZEOLITES (NATURAL)

(Data in metric tons unless otherwise noted)

Domestic Production and Use: In 2017, 8 companies in the United States operated 11 zeolite mines and produced an estimated 79,000 tons of natural zeolites, an 8% increase from that of 2016. One other company might also have mined zeolites, but specific information on the operational status was not available. Chabazite was mined in Arizona, and clinoptilolite was mined in California, Idaho, New Mexico, Oregon, and Texas. New Mexico was estimated to be the leading natural zeolite-producing State, followed by California, Idaho, Texas, Oregon, and Arizona. The top three U.S. companies accounted for approximately 85% of total domestic production.

An estimated 77,000 tons of natural zeolites were sold in the United States during 2017, an increase of 11% compared with sales in 2016. Domestic uses were, in decreasing order by estimated quantity, animal feed, water purification, odor control, unclassified end uses, oil and grease absorbent, fungicide or pesticide carrier, pet litter, wastewater treatment, gas absorbent (and air filtration), fertilizer carrier, soil amendment, aquaculture, and desiccant. Animal feed, odor control, and water purification applications likely accounted for about 75% of the domestic sales tonnage.

Salient Statistics—United States:	2013	2014	2015	2016	2017[e]
Production, mine	69,500	62,800	75,100	73,400	79,000
Sales, mill	68,300	62,500	73,200	69,500	77,000
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[e, 1]	68,300	62,500	73,200	69,500	77,000
Price, range of value, dollars per metric ton[2]	50–800	110–440	110–950	100–400	100–400
Employment, mine and mill[e, 3]	105	95	100	115	110
Net import reliance[4] as a percentage of estimated consumption	E	E	E	E	E

Recycling: Zeolites used for desiccation, gas absorbance, wastewater cleanup, and water purification may be reused after reprocessing of the spent zeolites. Information about the quantity of recycled natural zeolites was unavailable.

Import Sources (2013–16): Comprehensive trade data were not available for natural zeolite minerals because they were imported and exported under a generic U.S. Census Bureau Harmonized Tariff Schedule code that includes multiple mineral commodities. Nearly all imports and exports consisted of synthetic zeolites.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Mineral substances not elsewhere specified or included	2530.90.8050	Free.

Depletion Allowance: 14% (Domestic and foreign).

Government Stockpile: None.

Events, Trends, and Issues: Prior to the 1990s, annual output of natural zeolites in the United States was less than 15,000 tons. Production rose nearly fivefold from 1990 through 2016, owing predominantly to increases in animal feed sales, although sales for odor control, wastewater treatment, and water purification applications also increased. In contrast, sales for pet litter declined during this period as a result of competition from other products.

In 2017, one major U.S. company that mines in California finished construction of a new processing plant with an annual capacity of more than 35,000 tons, a tenfold increase in comparison to the former plant. The company will begin a project to further expand its production capacity in February 2018. Another leading company reported that sales of natural zeolites for animal feed, synthetic turf, wastewater treatment, and water purification were increasing rapidly. In Canada, multiple companies acquired rights to develop properties with significant resources of natural zeolites.

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ZEOLITES (NATURAL)

World Mine Production and Reserves: Most countries either do not report production of natural zeolites or production is reported with a 2- to 3-year lag time. Countries that mine large tonnages of zeolites typically use them in low-value, high-volume construction applications, such as dimension stone, lightweight aggregate, and pozzolanic cement. As a result, production data for some countries do not accurately indicate the quantities of natural zeolites used in the high-value applications that are reflected in the domestic production data.

World reserves of natural zeolites have not been estimated. Deposits occur in many countries, but companies rarely, if ever, publish reserves data. Further complicating estimates of reserves is the fact 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 the deposit valuable.

Production of natural zeolites in China was revised significantly downward for the past several years owing to new information from a Government source. Output from China had previously been estimated at roughly 2 million tons per year. China remained the leading global producer of natural zeolites, accounting for nearly 30% of estimated worldwide production.

	Mine production[e]		Reserves[5]
	2016	2017	
United States	[6]73,400	79,000	World reserve data are unavailable but are estimated to be large.
China	300,000	300,000	
Cuba	51,000	55,000	
Jordan	13,000	13,000	
Korea, Republic of	191,000	200,000	
New Zealand	80,000	80,000	
Turkey	55,000	60,000	
Other countries	350,000	350,000	
World total (rounded)	1,100,000	1,100,000	

World Resources: Recent estimates for domestic and global resources of natural zeolites are not available. Resources of chabazite, clinoptilolite, erionite, mordenite, and phillipsite within the Basin and Range province 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 zeolite 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.
[2]Range of ex-works mine and mill unit values for individual natural zeolite operations, based on data reported by U.S. producers. Unit values for most operations have varied from $100 to $230 per ton in the past 5 years. 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 office staff.
[4]Defined as imports – exports.
[5]See Appendix C for resource and reserve definitions and information concerning data sources.
[6]Reported figure.

ZINC

(Data in thousand metric tons of zinc content unless otherwise noted)

Domestic Production and Use: The value of zinc mined in 2017, based on zinc contained in concentrate, was about $2.17 billion. Zinc was mined in five States at 14 mines operated by four companies. Two smelter facilities, one primary and one secondary, operated by two companies, produced commercial-grade zinc metal. Of the total reported zinc consumed, most was used in galvanizing, followed by brass and bronze, zinc-base alloys, and other uses.

Salient Statistics—United States:	**2013**	**2014**	**2015**	**2016**	**2017[e]**
Production:					
Zinc in ore and concentrate	784	831	825	805	730
Refined zinc[1]	233	180	172	126	130
Imports for consumption:					
Zinc in ore and concentrate	2	([2])	([2])	([2])	10
Refined zinc	713	805	771	713	770
Exports:					
Zinc in ore and concentrate	669	644	708	597	630
Refined zinc	12	20	13	47	36
Shipments from Government stockpile	—	—	—	—	—
Consumption, apparent, refined zinc[3]	935	965	931	792	870
Price, average, cents per pound:					
North American[4]	95.6	107.1	95.5	101.4	134.1
London Metal Exchange (LME), cash	86.6	98.1	87.6	94.8	126.1
Reported producer and consumer stocks, refined zinc, yearend	74	88	87	84	80
Employment:					
Mine and mill, number[5]	2,560	2,620	2,680	2,350	2,590
Smelter, primary, number	257	259	250	246	250
Net import reliance[6] as a percentage of apparent consumption (refined zinc)	75	81	81	84	85

Recycling: In 2017, about 25% (33,000 tons) of the refined zinc produced in the United States was recovered from secondary materials at both primary and secondary smelters. Secondary materials included galvanizing residues and crude zinc oxide recovered from electric arc furnace dust.

Import Sources (2013–16): Ore and concentrate: Canada, 99%; and other, 1%. Refined metal: Canada, 73%; Mexico, 14%; Peru, 8%; Australia, 4%; and other, 1%. Waste and scrap: Canada, 72%; Mexico, 27%; and other, 1%. Combined total: Canada, 73%; Mexico, 14%; Peru, 8%; Australia, 4%; and other, 1%.

Tariff: **Item**	**Number**	**Normal Trade Relations 12–31–17**
Zinc ores and concentrates, Zn content	2608.00.0030	Free.
Zinc oxide; zinc peroxide	2817.00.0000	Free.
Unwrought zinc, not alloyed:		
Containing 99.99% or more zinc	7901.11.0000	1.5% ad val.
Containing less than 99.99% zinc:		
Casting-grade	7901.12.1000	3% ad val.
Other	7901.12.5000	1.5% ad val.
Zinc alloys	7901.20.0000	3% ad val.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile:

Stockpile Status—9–30–17[7]

Material	**Inventory**	**Disposal Plan FY 2017**	**Disposals FY 2017**
Zinc	7.25	7.25	—

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ZINC

Events, Trends, and Issues: Global zinc mine production in 2017 was estimated to be 13.2 million tons, a 5% increase from that of 2016. Zinc mine production in India increased significantly owing to the completion of the Rampura Agucha underground mine. Other notable zinc mine production increases took place at the Bisha Mine in Eritrea and at the Antamina Mine in Peru. In 2017, the zinc metal market continued the deficit observed in 2016, with consumption exceeding production. According to the International Lead and Zinc Study Group,[8] global refined zinc production in 2017 was estimated to be 13.53 million tons, and metal consumption was estimated to be 13.93 million tons, resulting in a production-to-consumption deficit of 400,000 tons of refined zinc. Domestic zinc mine production decreased by 9% in 2017 owing to the ongoing strike at the Lucky Friday Mine in Idaho and decreased output at the Red Dog Mine in Alaska. Refined zinc production increased by 6% as a result of production resuming at the Middle Tennessee Mines and increased production at the Clarksville, TN, smelter. As reflected by higher domestic refined production and imports, calculated apparent consumption increased by 9% to 870,000 tons.

Coincident with increased investment interest and the production to consumption deficit in 2016, the monthly average North American Special High Grade zinc price increased by about 16% in the first 9 months of 2017 to an average of $1.50 per pound in September from $1.29 per pound in January.

World Mine Production and Reserves: Reserves for Bolivia, Canada, India, Kazakhstan, Mexico, Sweden, the United States, and other countries were revised based on company data. The reserves estimates for Australia, China, and Peru were revised based on data from Government reports.

	Mine production[9]		Reserves[10]
	2016	2017[e]	
United States	805	730	9,700
Australia	965	1,000	[11]64,000
Bolivia	490	500	4,800
Canada	322	340	5,400
China	4,800	5,100	41,000
India	682	1,300	11,000
Kazakhstan	340	360	13,000
Mexico	670	680	20,000
Peru	1,330	1,400	28,000
Sweden	257	260	3,800
Other countries	1,890	1,520	33,000
World total (rounded)	12,600	13,200	230,000

World Resources: Identified zinc resources of the world are about 1.9 billion tons.

Substitutes: Aluminum and plastics substitute for galvanized sheet in automobiles; and aluminum alloys, cadmium, paint, and plastic coatings replace zinc coatings in other applications. Aluminum- and magnesium-base alloys are major competitors for zinc-base die-casting alloys. Many elements are substitutes for zinc in chemical, electronic, and pigment uses.

[e]Estimated. — Zero.
[1]Includes primary and secondary refined production.
[2]Less than ½ unit.
[3]Defined as refined production + refined imports – refined exports + adjustments for Government stock changes.
[4]Platts Metals Week price for North American SHG zinc; based on the LME cash price plus premium.
[5]Includes mine and mill employment at all zinc-producing mines. Source: Mine Safety and Health Administration.
[6]Defined as imports – exports + adjustments for Government stock changes.
[7]See Appendix B for definitions.
[8]International Lead and Zinc Study Group, 2017, ILZSG session/forecasts: Lisbon, Portugal, International Lead and Zinc Study Group press release, October 30, 5 p.
[9]Zinc content of concentrate and direct shipping ore.
[10]See Appendix C for resource and reserve definitions and information concerning data sources.
[11]For Australia, Joint Ore Reserves Committee-compliant reserves were about 24 million tons.

ZIRCONIUM AND HAFNIUM

(Data in metric tons unless otherwise noted)

Domestic Production and Use: In 2017, two firms recovered zircon (zirconium silicate) from surface-mining operations in Florida and Georgia as a coproduct from the mining of heavy-mineral sands and the processing of titanium and zirconium mineral concentrates, and a third company began processing existing mineral sands tailings in Florida. Zirconium metal and hafnium metal were produced from zirconium chemical intermediates by one domestic producer in Oregon and one in Utah. Typically, zirconium and hafnium are contained in zircon at a ratio of about 50 to 1. Zirconium chemicals were produced by the metal producer in Oregon and by at least 10 other companies. Ceramics, foundry sand, opacifiers, and refractories are the leading end uses for zircon. Other end uses of zircon include abrasives, chemicals (predominantly, zirconium oxychloride octohydrate and zirconium basic sulfate as intermediate 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:	2013	2014	2015	2016	2017[e]
Production, zircon (ZrO_2 content)[1]	W	W	[2]50,000	W	[2]30,000
Imports:					
Zirconium, ores and concentrates (ZrO_2 content)	8,050	32,800	20,800	24,900	28,000
Zirconium, unwrought, powder, and waste and scrap	395	843	1,140	1,040	840
Zirconium, wrought	321	257	171	195	240
Hafnium, unwrought, powder, and waste and scrap	10	21	72	180	160
Exports:					
Zirconium ores and concentrates (ZrO_2 content)	19,000	4,850	3,200	3,280	11,000
Zirconium, unwrought, powder, and waste and scrap	599	534	515	363	550
Zirconium, wrought	1,140	913	1,020	788	630
Consumption, apparent, zirconium ores and concentrates, (ZrO_2 content)[3]	W	W	[2]70,000	W	[2]50,000
Prices:					
Zircon, dollars per metric ton (gross weight):					
Domestic[4]	1,050	1,050	1,025	1,025	1,025
Imported[5]	996	1,133	1,061	877	881
Zirconium, unwrought, import, France, dollars per kilogram[6]	75	59	50	46	46
Hafnium, unwrought, import, France, dollars per kilogram[6]	578	561	607	[7]NA	[7]NA
Hafnium, unwrought, dollars per kilogram[8]	NA	NA	NA	1,088	912
Net import reliance[9] as a percentage of apparent consumption:					
Zirconium	E	<50	<25	<50	<50
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. Hafnium metal recycling was insignificant.

Import Sources (2013–16): Zirconium ores and concentrates: South Africa, 59%; Australia, 22%; Senegal, 14%; and other, 5%. Zirconium, unwrought, including powder: China, 67%; Germany, 16%; Japan, 12%; and other, 5%. Hafnium, unwrought: Germany, 46%; France, 32%; United Kingdom, 15%; China, 6%; and other, 1%.

Tariff: Item	Number	Normal Trade Relations 12–31–17
Zirconium ores and concentrates	2615.10.0000	Free.
Ferrozirconium	7202.99.1000	4.2% ad val.
Zirconium, unwrought and zirconium powder	8109.20.0000	4.2% ad val.
Zirconium waste and scrap	8109.30.0000	Free.
Other zirconium articles	8109.90.0000	3.7% ad val.
Hafnium, unwrought, powder, and waste and scrap	8112.92.2000	Free.

Depletion Allowance: 22% (Domestic), 14% (Foreign).

Government Stockpile: None.

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ZIRCONIUM AND HAFNIUM

Events, Trends, and Issues: Domestic mining and production of zircon concentrates took place at one mine near Starke, FL, and one mine near Nahunta, GA. Production of zircon concentrates increased in 2017 as compared with 2016 owing to a third company which began processing existing mineral sands tailings in Starke, FL. Prices for zircon concentrates were almost unchanged during the year. Apparent consumption was estimated to have increased in 2017, but exports were estimated to have tripled in 2017 because of increased production of zircon concentrates in Florida.

Construction at the Thunderbird Project in Western Australia was expected to begin by yearend 2017. Thunderbird was expected to produce about 50,000 tons per year of zircon concentrate in the first 5 years of operation. In New South Wales, Australia, construction of the Dubbo Zirconia Project (DZP) was also expected to begin in late 2017. The DZP was projected to produce zirconium carbonate (equivalent to 16,300 tons per year of ZrO_2) and more than 200 tons per year of hafnium oxide (HfO_2), as well as niobium, rare-earth, and tantalum products. Production of hafnium metal from HfO_2 at the DZP would be independent of zirconium metal refinement for the nuclear industry where it is a byproduct. Additional heavy-mineral exploration and mining projects were underway in Australia, Mozambique, Sri Lanka, and Tanzania.

World Mine Production and Reserves: World primary hafnium production data are not available. Zirconium reserves for Australia were revised based on data from Geoscience Australia. Reserves for Mozambique were revised based on company reports. Although hafnium occurs with zirconium in the minerals zircon and baddeleyite, quantitative estimates of hafnium reserves are not available.

	Zirconium concentrates, mine production (thousand metric tons, gross weight)		Zirconium reserves[10] (thousand metric tons, ZrO_2)
	2016	2017[e]	
United States	W	[2]50	500
Australia	450	600	47,000
China	140	140	500
India	40	40	3,400
Indonesia	110	120	NA
Mozambique	68	75	1,800
Senegal	53	60	NA
South Africa	360	400	14,000
Other countries	96	110	7,200
World total (rounded)	[11]1,320	1,600	74,000

World Resources: 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 are 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. Silver-cadmium-indium control rods are used in lieu of hafnium at numerous nuclear powerplants. Zirconium can be used interchangeably with hafnium in certain superalloys.

[e]Estimated. E Net Exporter. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Contained ZrO_2 content calculated at 65% of gross production.
[2]Rounded to one significant digit to avoid disclosing company proprietary data.
[3]Defined as production + imports – exports.
[4]Source: Industrial Minerals, yearend average of high-low price range.
[5]Unit value based on U.S. imports for consumption from Australia, Senegal, and South Africa.
[6]Unit value based on U.S. imports for consumption from France.
[7]Increased imports include unspecified hafnium-containing materials, alloys, and misclassified items.
[8]Source: Argus Media group–Argus Metals International, minimum 99% hafnium, at warehouse (Rotterdam).
[9]Defined as imports – exports.
[10]See Appendix C for resource and reserve definitions and information concerning data sources.
[11]Excludes U.S. production.

APPENDIX A

Abbreviations and Units of Measure

1 carat (metric) (diamond)	= 200 milligrams
1 flask (fl)	= 76 pounds, avoirdupois
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
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 Helium Stockpile

Inventory refers to the quantity of mineral materials held in the National Defense Stockpile or in the Federal Helium Reserve. Nonstockpile-grade materials may be included in the table; where significant, the quantities of these stockpiled materials will be specified in the text accompanying the table.

Authorized for disposal refers to quantities that are in excess of the stockpile goal for a material, and for which 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.

Disposal plan FY 2017 indicates the total amount of a material in the National Defense Stockpile that the U.S. Department of Defense is permitted to sell under the Annual Materials Plan approved by Congress for the fiscal year (FY). FY 2017 is the period from October 1, 2016, through September 30, 2017. For mineral commodities that have a disposal plan greater than the inventory, the actual quantity will be limited to the remaining disposal authority or inventory. Note that, unlike the National Defense Stockpile, helium stockpile sales by the Bureau of Land Management under the Helium Privatization Act of 1996 are permitted to exceed disposal plans.

Disposals FY 2017 refers to material sold or traded from the stockpile in FY 2017.

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, almost 520 million tons of copper have been produced worldwide, but world copper reserves in 2017 were estimated to be 790 million tons of copper, more than double those of 1970, despite the depletion by mining of more than the original 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. USGS reports provide estimates of undiscovered mineral resources using a three-part assessment methodology (Singer and Menzie, 2010). Mineral-resource assessments have been carried out for small parcels of land being evaluated for land reclassification, for the Nation, and for the world.

Reference Cited

Singer, D.A., and Menzie, W.D., 2010, Quantitative mineral resource assessments—An integrated approach: Oxford, United Kingdom, Oxford University Press, 219 p.

Part A—Resource/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 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/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 1 and 2; 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/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 whose 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.

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 measurement 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 which 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/Reserves.—That part of any resource/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 1 and 2. In figure 1, 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, percent extractable, 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 1 and 2. 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 1.—Major Elements of Mineral-Resource Classification, Excluding *Reserve Base* and *Inferred Reserve Base*

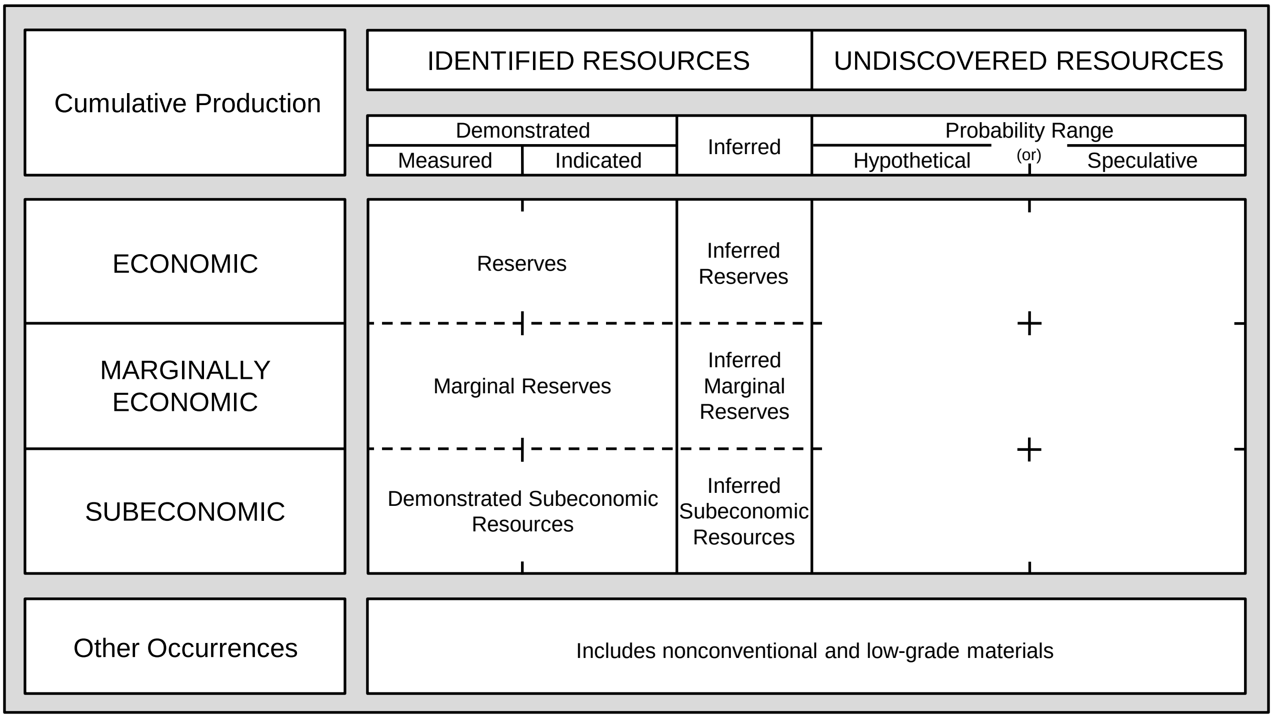
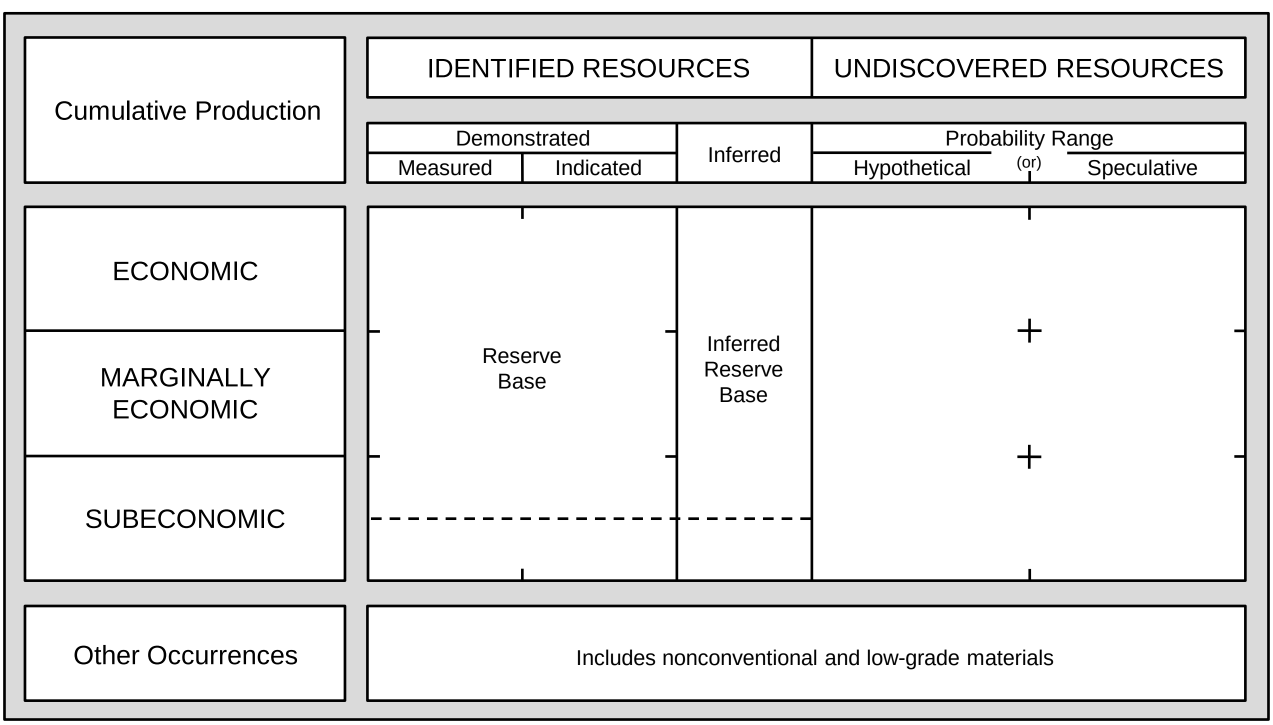


Figure 2.—*Reserve Base* and *Inferred Reserve Base* Classification Categories



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 information about the quantity and quality of mineral resources but does not directly measure reserves, and companies or governments do not directly report reserves to the USGS. Reassessment of reserves is a continuing process, and the intensity of this process differs for mineral commodities, countries, 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 (the 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 (http://www.jorc.org/).

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 Mineral Commodity Summaries 2018 are Accessible EDR. For more information, see table 3. Australia's Identified Mineral Resources as of December 2016 can be found at http://www.ga.gov.au/scientific-topics/minerals/table-3-mineral-resources.

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 http://web.cim.org/standards/MenuPage.cfm?sections=177&menu=178.

Russian reserves for most minerals, which had been withheld, have been released with increasing frequency within the past few years and can appear in a number of sources, although no systematic list of Russian reserves is published. Russian reserves data for various minerals appear at times in journal articles, such as those in the journal Mineral'nye Resursy Rossii (Mineral Resources of Russia), which is published by the Russian Ministry of Natural Resources. Russian reserves data are often published according to the Soviet reserves classification system, which is still used in many countries of the former Soviet Union, but also at times published according to the JORC system based on analyses made by Western firms. 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, as 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 reserves that are included. 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 (economic reserves or balansovye zapasy) and outside the balance reserves (uneconomic reserves or zabalansovye zapasy), 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	James J. Barry
Bahrain	Loyd M. Trimmer III
Benin	Alberto A. Perez
Botswana	Thomas R. Yager
Burkina Faso	Alberto A. Perez
Burundi	Thomas R. Yager
Cameroon	James J. Barry
Cabo Verde	Alberto A. Perez
Central African Republic	James J.Barry
Chad	Loyd M. Trimmer III
Comoros	James J. Barry
Congo (Brazzaville)	James J. Barry
Congo (Kinshasa)	Thomas R. Yager
Côte d'Ivoire	Alberto A. Perez
Djibouti	Thomas R. Yager
Egypt	Mowafa Taib
Equatorial Guinea	James J. Barry
Eritrea	Thomas R. Yager
Ethiopia	Thomas R. Yager
Gabon	James J. Barry
The Gambia	Alberto A. Perez
Ghana	Omayra Bermúdez-Lugo
Guinea	Alberto A. Perez
Guinea-Bissau	Alberto A. Perez
Iran	Loyd M. Trimmer III
Iraq	Loyd M. Trimmer III
Israel	Loyd M. Trimmer III
Jordan	Mowafa Taib
Kenya	Thomas R. Yager
Kuwait	Loyd M. Trimmer III
Lebanon	Mowafa Taib
Lesotho	James J. Barry
Liberia	Loyd M. Trimmer III
Libya	Mowafa Taib
Madagascar	Thomas R. Yager
Malawi	Thomas R. Yager
Mali	Philip Szczesniak
Mauritania	Mowafa Taib
Mauritius	James J. Barry
Morocco & Western Sahara	Mowafa Taib
Mozambique	Thomas R. Yager
Namibia	James J. Barry
Niger	Philip Szczesniak
Nigeria	Thomas R. Yager
Oman	Loyd M. Trimmer III
Qatar	Loyd M. Trimmer III
Reunion	James J. Barry
Rwanda	Thomas R. Yager
São Tomé & Principe	Alberto A. Perez
Saudi Arabia	Mowafa Taib
Senegal	Alberto A. Perez
Seychelles	James J. Barry
Sierra Leone	Loyd M. Trimmer III
Somalia	Loyd M. Trimmer III
South Africa	Thomas R. Yager
South Sudan	Mowafa Taib
Sudan	Mowafa Taib
Swaziland	James J. Barry
Syria	Mowafa Taib
Tanzania	Thomas R. Yager
Togo	Alberto A. Perez
Tunisia	Mowafa Taib
Uganda	Thomas R. Yager
United Arab Emirates	Loyd M. Trimmer III
Yemen	Mowafa Taib
Zambia	James J. Barry
Zimbabwe	James J. Barry

Asia and the Pacific

Afghanistan	Karine M. Renaud
Australia	Spencer D. Buteyn
Bangladesh	Yolanda Fong-Sam
Bhutan	Yolanda Fong-Sam
Brunei	Spencer D. Buteyn
Burma (Myanmar)	Yolanda Fong-Sam
Cambodia	Yolanda Fong-Sam
China	Sean Xun
Fiji	Meralis Plaza-Toledo
India	Karine M. Renaud
Indonesia	Meralis Plaza-Toledo
Japan	Spencer D. Buteyn
Korea, North	Spencer D. Buteyn
Korea, Republic of	Spencer D. Buteyn
Laos	Yolanda Fong-Sam
Malaysia	Spencer D. Buteyn
Mongolia	Meralis Plaza-Toledo
Nauru	Spencer D. Buteyn
Nepal	Yolanda Fong-Sam
New Caledonia	Meralis Plaza-Toledo
New Zealand	Spencer D. Buteyn
Pakistan	Karine M. Renaud
Papua New Guinea	Meralis Plaza-Toledo
Philippines	Yolanda Fong-Sam
Singapore	Spencer D. Buteyn
Solomon Islands	Karine M. Renaud
Sri Lanka	Karine M. Renaud
Taiwan	Spencer D. Buteyn
Thailand	Yolanda Fong-Sam
Timor Leste	Meralis Plaza-Toledo
Vietnam	Yolanda Fong-Sam

Europe and Central Eurasia

Albania	Sinan Hastorun
Armenia	Elena Safirova
Austria	Sinan Hastorun
Azerbaijan	Elena Safirova
Belarus	Elena Safirova

Europe and Central Eurasia—continued

Belgium	Sinan Hastorun
Bosnia and Herzegovina	Lindsey Abdale
Bulgaria	Karine M. Renaud
Croatia	Lindsey Abdale
Cyprus	Sinan Hastorun
Czechia	Lindsey Abdale
Denmark, Faroe Islands, and Greenland	Meralis Plaza-Toledo
Estonia	Lindsey Abdale
Finland	Yolanda Fong-Sam
France	Karine M. Renaud
Georgia	Elena Safirova
Germany	Elena Safirova
Greece	Sinan Hastorun
Hungary	Sinan Hastorun
Iceland	Meralis Plaza-Toledo
Ireland	Yolanda Fong-Sam
Italy	Elena Safirova
Kazakhstan	Elena Safirova
Kosovo	Sinan Hastorun
Kyrgyzstan	Karine M. Renaud
Latvia	Lindsey Abdale
Lithuania	Lindsey Abdale
Luxembourg	Sinan Hastorun
Macedonia	Lindsey Abdale
Malta	Sinan Hastorun
Moldova	Elena Safirova
Montenegro	Sinan Hastorun
Netherlands	Sinan Hastorun
Norway	Meralis Plaza-Toledo
Poland	Lindsey Abdale
Portugal	Lindsey Abdale
Romania	Lindsey Abdale
Russia	Elena Safirova
Serbia	Karine M. Renaud
Slovakia	Lindsey Abdale
Slovenia	Lindsey Abdale
Spain	Meralis Plaza-Toledo
Sweden	Meralis Plaza-Toledo
Switzerland	Sinan Hastorun
Tajikistan	Karine M. Renaud
Turkey	Sinan Hastorun
Turkmenistan	Karine M. Renaud
Ukraine	Elena Safirova
United Kingdom	Lindsey Abdale
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