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

# MINERAL COMMODITY SUMMARIES 2015

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
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Mercury
Mica
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Niobium
Nitrogen
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Phosphate Rock
Platinum
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Rare Earths
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Salt
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Silicon
Silver
Soda Ash
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Strontium
Sulfur
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Tantalum
Tellurium
Thallium
Thorium
Tin
Titanium
Tungsten
Vanadium
Vermiculite
Wollastonite
Yttrium
Zeolites
Zinc
Zirconium

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# INSTANT INFORMATION

Information about the U.S. Geological Survey, its programs, staff, and products is available from the Internet at <http://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 <http://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. 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. 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, distribution, stocks, and consumption of significant mineral commodities. 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.

*Nonmetallic Mineral Products Industry Indexes*—This monthly publication analyzes the leading and coincident indexes for the nonmetallic mineral products industry (NAICS 327).

*Materials Flow Studies*—These publications describe the flow of materials from source to ultimate disposition to help better understand the economy, manage the use of natural resources, and protect the environment.

*Recycling Reports*—These materials flow studies illustrate the recycling of metal commodities and identify recycling trends.

*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.

# WHERE TO OBTAIN PUBLICATIONS

- *Mineral Commodity Summaries* and the *Minerals Yearbook* are sold by the U.S. Government Printing Office. Orders are accepted over the Internet at <http://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 <http://minerals.usgs.gov/minerals>.

# INTRODUCTION

Each chapter of the 2015 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 2014 mineral production data for the world. More than 90 individual minerals and materials are covered by two-page synopses.

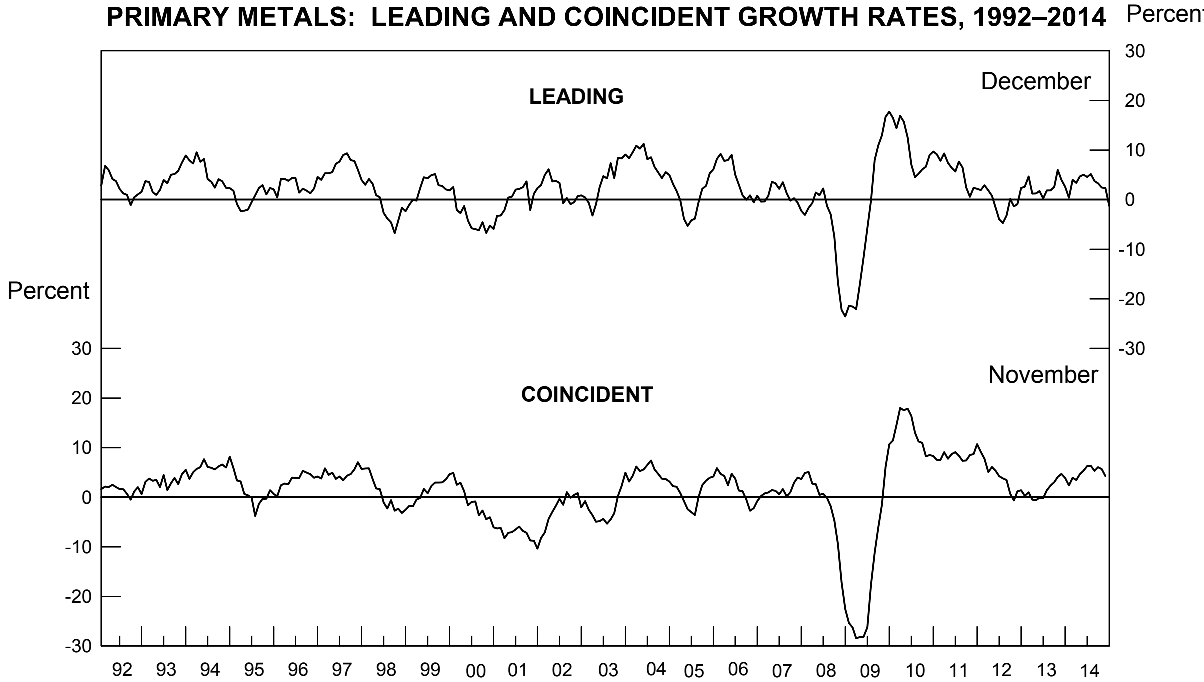
For mineral commodities for which there is a Government stockpile, detailed information concerning the stockpile status is included in the two-page synopsis.

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.

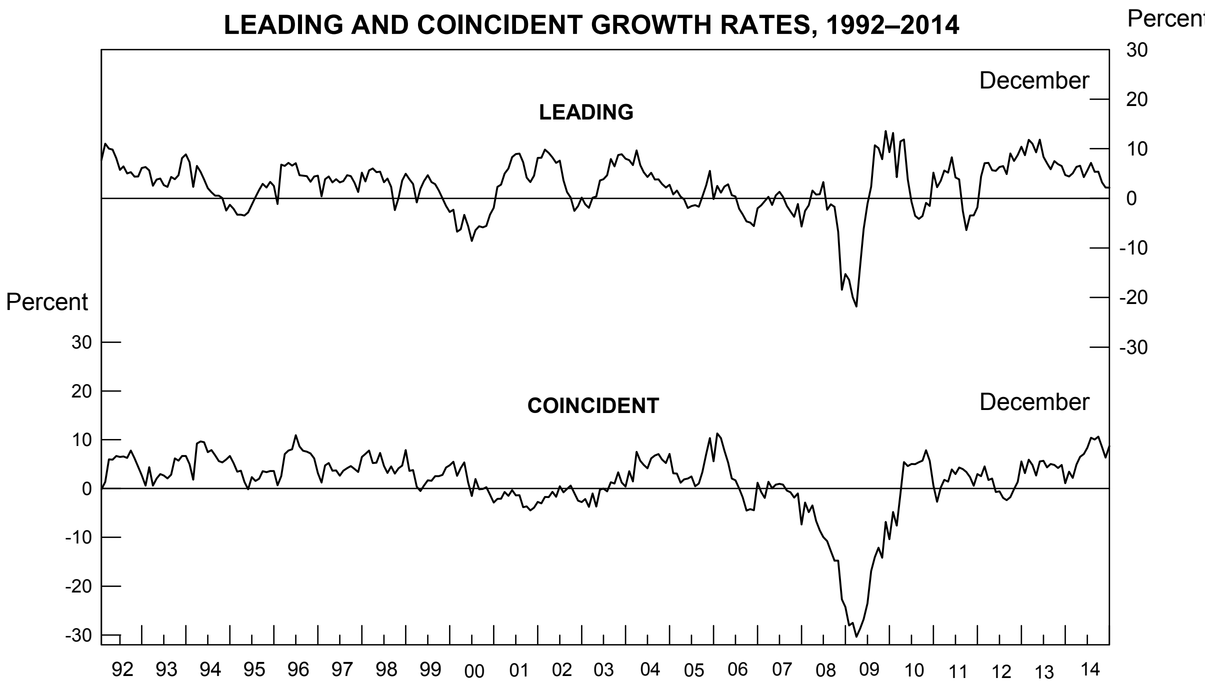
The USGS continually strives to improve the value of its publications to users. Constructive comments and suggestions by readers of the MCS 2015 are welcomed.

# GROWTH RATES OF LEADING AND COINCIDENT INDEXES FOR MINERAL PRODUCTS

**PRIMARY METALS: LEADING AND COINCIDENT GROWTH RATES, 1992–2014**




**NONMETALLIC MINERAL PRODUCTS: LEADING AND COINCIDENT GROWTH RATES, 1992–2014**

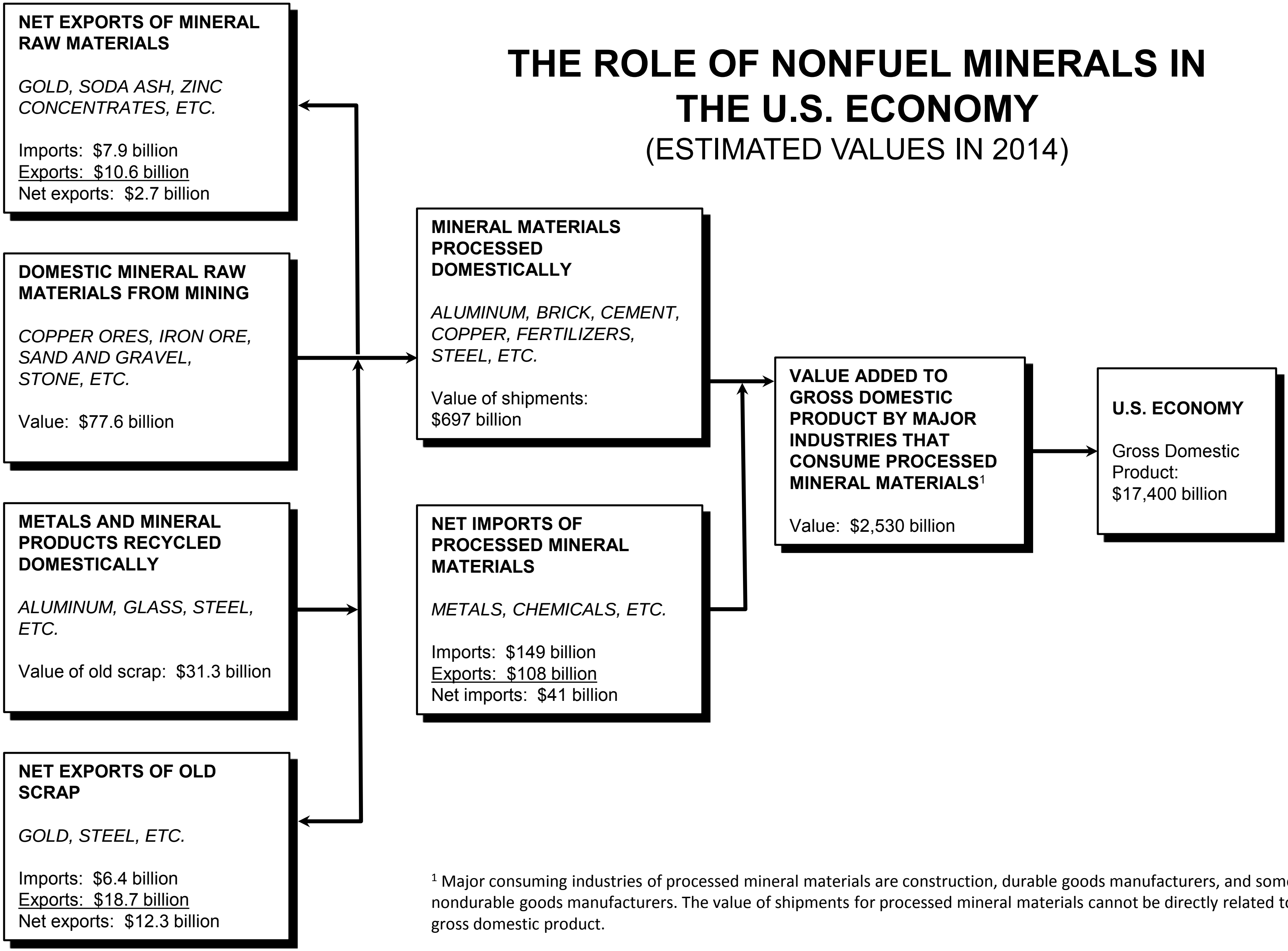



The leading indexes historically give signals several months in advance of major changes in the corresponding coincident index, which measures current industry activity. The growth rates, which can be viewed as trends, are expressed as compound annual rates based on the ratio of the current month's index 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 2014)




[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

# 2014 U.S. NET IMPORT RELIANCE[1]

| Commodity | Percent | Major import sources (2010–13)[2] |
|---|---|---|
| ARSENIC | 100 | Morocco, China, Belgium |
| ASBESTOS | 100 | Brazil, Canada |
| BAUXITE | 100 | Jamaica, Brazil, Guinea, Australia |
| CESIUM | 100 | Canada |
| FLUORSPAR | 100 | Mexico, China, South Africa, Mongolia |
| GRAPHITE (natural) | 100 | China, Mexico, Canada, Brazil |
| INDIUM | 100 | China, Canada, Belgium, Japan |
| IODINE | 100 | Chile, Japan |
| MANGANESE | 100 | South Africa, Gabon, Australia, Georgia |
| MICA, sheet (natural) | 100 | India, China |
| NIOBIUM (columbium) | 100 | Brazil, Canada |
| QUARTZ CRYSTAL (industrial) | 100 | China, Japan, Romania, United Kingdom |
| RUBIDIUM | 100 | Canada |
| SCANDIUM | 100 | China |
| STRONTIUM | 100 | Mexico, Germany, China |
| TANTALUM | 100 | China, Germany, Kazakhstan, Russia |
| THALLIUM | 100 | Germany, Russia |
| THORIUM | 100 | India, France |
| VANADIUM | 100 | Czech Rep., Canada, Rep. of Korea, Austria |
| GALLIUM | 99 | Germany, United Kingdom, China, Ukraine |
| GEMSTONES | 97 | Israel, India, Belgium, South Africa |
| GERMANIUM | 95 | China, Belgium, Russia, Canada |
| BISMUTH | 94 | China, Belgium, Peru, United Kingdom |
| TITANIUM MINERAL CONCENTRATES | 91 | South Africa, Australia, Canada, Mozambique |
| DIAMOND (dust grit, and powder) | 86 | China, Ireland, Rep. of Korea, Romania |
| PLATINUM | 85 | Germany, South Africa, United Kingdom, Canada |
| ANTIMONY | 84 | China, Belgium, Mexico, Bolivia |
| POTASH | 84 | Canada, Russia, Israel, Chile |
| GARNET (industrial) | 83 | Australia, India, China |
| RHENIUM | 83 | Chile, Poland, United Kingdom |
| STONE (dimension) | 83 | China, Brazil, Italy, Turkey |
| ZINC | 81 | Canada, Mexico, Peru |
| BARITE | 79 | China, India, Morocco, Mexico |
| SILICON CARBIDE (crude) | 77 | China, South Africa, Netherlands, Romania |
| COBALT | 76 | China, Norway, Russia, Finland |
| TIN | 74 | Peru, Bolivia, Indonesia, Malaysia |
| CHROMIUM | 72 | South Africa, Kazakhstan, Russia, Mexico |
| PALLADIUM | 65 | Russia, South Africa, United Kingdom, Norway |
| PEAT | 64 | Canada |
| SILVER | 63 | Mexico, Canada, Poland, Peru |
| RARE EARTHS[3] | 59 | China, France, Japan, Estonia |
| NICKEL | 54 | Canada, Russia, Australia, Norway |
| TITANIUM (sponge) | 51 | Japan, Kazakhstan, China |
| MAGNESIUM COMPOUNDS | 43 | China, Brazil, Australia, Canada |
| TUNGSTEN | 43 | China, Bolivia, Canada, Germany |
| SILICON | 40 | Russia, Brazil, Canada, Venezuela |
| NITROGEN (fixed)—AMMONIA | 36 | Trinidad and Tobago, Canada, Russia, Ukraine |
| ALUMINUM | 33 | Canada, Russia, United Arab Emirates, China |
| COPPER | 31 | Chile, Canada, Mexico, Peru |
| MICA, scrap and flake (natural) | 31 | Canada, China, Finland, Mexico |
| LEAD | 30 | Canada, Mexico, Australia |
| MAGNESIUM METAL | 30 | Israel, Canada, China, United Kingdom |
| SALT | 28 | Canada, Chile, Mexico, The Bahamas |
| VERMICULITE | 25 | South Africa, Brazil, China |
| PERLITE | 24 | Greece |
| IRON and STEEL | 17 | Canada, Mexico, Rep. of Korea, Brazil |
| PHOSPHATE ROCK | 15 | Morocco, Peru |
| PUMICE | 13 | Greece, Iceland, Mexico |
| TALC | 12 | China, Canada, Pakistan |
| BERYLLIUM | 11 | Russia, Kazakhstan, China, Japan |
| SULFUR | 11 | Canada, Mexico, Venezuela |
| GYPSUM | 10 | Canada, Mexico, Spain |
| IRON and STEEL SLAG | 8 | Canada, Japan, Spain, Italy |
| CEMENT | 7 | Canada, Rep. of Korea, China, Greece |

[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 (for example, molybdenum) or less than 5% import reliant (for example, lime). For some mineral commodities (for example, hafnium), not enough information is available to calculate the exact percentage of import reliance; for others (for example, tellurium), exact percentages may have been rounded to avoid disclosing company proprietary data.

[2]In descending order of import share.

[3]Data include lanthanides and yttrium but exclude most scandium.

# SIGNIFICANT EVENTS, TRENDS, AND ISSUES

In 2014, the estimated value of total nonfuel mineral production increased in the United States. The quantity of production increased for most mineral commodities mined in the United States. Prices increased for the majority of mineral commodities, but notable exceptions were the declines in prices for most precious metals. Minerals remained fundamental to the U.S. economy, contributing to the real gross domestic product (GDP) at several levels, including mining, processing, and manufacturing finished products. Following the reduction in construction activity that began with the 2008–09 recession and continued through 2011, the construction industry continued to expand in 2014, with increased production and consumption of cement, construction sand and gravel, crushed stone, and gypsum, mineral commodities that are used almost exclusively in construction.

The figure on page 4 shows that the primary metals industry and the nonmetallic minerals products industry are fundamentally cyclical. Growth rates are directly affected by the U.S. business cycle as well as by global economic conditions. The U.S. Geological Survey (USGS) generates composite indexes to measure economic activity in these industries. The coincident composite indexes describe the current situation using production, employment, and shipments data. The leading composite indexes signal major changes in the industry's direction by such variables as stock prices, commodity prices, new product orders, and other indicators, which are combined into one gauge. For each of the indexes, a growth rate is calculated to measure its change relative to the previous 12 months. The primary metals leading index growth rate started slowly in 2014, mainly because of the effect that severe weather had on U.S. business activity. It accelerated through mid-year; however, it turned down and settled in negative territory by yearend. U.S. economic growth supported the domestic primary metals industry; however, weak global economic growth and the strong U.S. dollar limited U.S. exports. Meanwhile, low-priced metal imports increased during most of 2014. Metals consumption in the manufacturing sector increased during the year; however, decreased new orders for durable goods in the latter part of the year will likely reduce metals demand in this sector in 2015. A rise in nonresidential construction projects also increased metals demand in 2014. One of the largest nonresidential construction activities in 2014 was manufacturing plant building. The nonmetallic mineral products industry also benefitted from this increase in construction spending in 2014. This offset some of the slower growth in the residential construction industry in 2014. However, in 2015, residential construction indicators, such as housing starts and building permits, point to increases in single-family home building, which is the largest portion of residential construction activity. The nonmetallic mineral products leading index growth rate ended 2014 indicating slow growth in the nonmetallic mineral products industry in 2015.

As shown in the figure on page 5, the estimated value of mineral raw materials produced at mines in the United States in 2014 was $77.6 billion, a 3.5% increase from $75.0 billion in 2013. Net exports of mineral raw materials and old scrap contributed an additional $15.0 billion to the U.S. economy. Domestic raw materials and domestically recycled materials were used to process mineral materials worth $697 billion. These mineral materials, including aluminum, brick, copper, fertilizers, and steel, and net imports of processed materials (worth about $41 billion) were, in turn, consumed by downstream industries with a value added of an estimated $2.53 trillion in 2014.

The estimated value of U.S. metal mine production in 2014 was $31.5 billion (table 1), slightly less than that of 2013. Principal contributors to the total value of metal mine production in 2014 were copper (32%), gold (27%), iron ore (16%), molybdenum (10%), and zinc (6%). Changes in average prices for domestically mined metals were mixed in 2014. After increased yearly average prices from 2002–12, gold prices decreased for the second consecutive year. The estimated value of U.S. industrial minerals mine production in 2014 was $46.1 billion, about 7% more than that of 2013. The value of industrial minerals mine production in 2013 was dominated by crushed stone (28%), cement (17%), and construction sand and gravel (15%). In general, industrial minerals prices increased slightly.

Mine production of 14 mineral commodities was worth more than $1 billion each in the United States in 2014. These were, in decreasing order of value, crushed stone, copper, gold, cement, construction sand and gravel, iron ore (shipped), industrial sand and gravel, molybdenum concentrates, phosphate rock, lime, salt, zinc, soda ash, and clays (all types).

The figure on page 6 illustrates the reliance of the United States on foreign sources for raw and processed mineral materials. In 2014, the supply for more than one-half of U.S. apparent consumption of 43 mineral commodities shown in the figure came from imports, and the United States was 100% import reliant for 19 of those. U.S. import reliance has increased significantly since 1978, the year that this information was first reported. At that time, the United States was 100% import reliant for 7 mineral commodities, and more than 50% import reliant for 25 mineral commodities. In 2014, the United States was a net exporter of 17 mineral commodities, meaning more of those domestically produced mineral commodities were exported than imported. That figure has remained relatively stable, with net exports of 18 mineral commodities in 1978.

In 2014, 12 States each produced more than $2 billion worth of nonfuel mineral commodities. These States were, in descending order of value—Arizona, Nevada, Minnesota, Texas, Utah, California, Alaska, Florida, Missouri, Michigan, Wyoming, and Colorado. The mineral production of these States accounted for 62% of the U.S. total output value (table 3)

### TABLE 1.—U.S. MINERAL INDUSTRY TRENDS

| | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Total mine production (million dollars): | | | | | |
| Metals | 30,300 | 36,000 | 34,700 | 32,100 | 31,500 |
| Industrial minerals | 36,200 | 38,800 | 40,900 | 42,900 | 46,100 |
| Coal | 38,600 | 44,900 | 40,600 | 36,600 | 37,700 |
| Employment (thousands of production workers): | | | | | |
| Coal mining | 70 | 78 | 74 | 68 | 67 |
| Metal mining | 29 | [1]98 | [1]101 | [1]100 | [1]100 |
| Industrial minerals, except fuels | 71 | [2]NA | [2]NA | [2]NA | [2]NA |
| Chemicals and allied products | 474 | 480 | 491 | 490 | 497 |
| Stone, clay, and glass products | 283 | 278 | 273 | 275 | 283 |
| Primary metal industries | 275 | 301 | 317 | 306 | 312 |
| Average weekly earnings of production workers (dollars): | | | | | |
| Coal mining | 1,365 | 1,404 | 1,348 | 1,361 | 1,440 |
| Chemicals and allied products | 888 | 911 | 910 | 919 | 918 |
| Stone, clay, and glass products | 727 | 767 | 766 | 782 | 827 |
| Primary metal industries | 880 | 889 | 907 | 960 | 989 |

[e]Estimated. NA Not available.

[1]Metal mining and industrial minerals (except fuel), combined.

[2]Because of changes to U.S. Department of Labor reports, these data are no longer available.

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

### TABLE 2.—U.S. MINERAL-RELATED ECONOMIC TRENDS

| | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Gross domestic product (billion dollars) | 14,964 | 15,518 | 16,163 | 16,768 | 17,393 |
| Industrial production (2007=100): | | | | | |
| Total index | 91 | 94 | 97 | 100 | 104 |
| Manufacturing: | 87 | 90 | 94 | 96 | 100 |
| Nonmetallic mineral products | 69 | 70 | 71 | 74 | 78 |
| Primary metals: | 91 | 97 | 100 | 101 | 106 |
| Iron and steel | 89 | 98 | 101 | 100 | 103 |
| Aluminum | 92 | 98 | 103 | 103 | 105 |
| Nonferrous metals (except aluminum) | 112 | 114 | 112 | 120 | 129 |
| Chemicals | 86 | 86 | 86 | 88 | 90 |
| Mining: | 101 | 107 | 114 | 119 | 130 |
| Coal | 94 | 95 | 88 | 86 | 85 |
| Oil and gas extraction | 110 | 115 | 127 | 137 | 154 |
| Metals | 96 | 98 | 99 | 99 | 100 |
| Nonmetallic minerals | 73 | 75 | 76 | 78 | 83 |
| Capacity utilization (percent): | | | | | |
| Total industry: | 74 | 76 | 77 | 78 | 79 |
| Mining: | 84 | 86 | 87 | 87 | 89 |
| Metals | 74 | 74 | 72 | 72 | 75 |
| Nonmetallic minerals | 70 | 75 | 78 | 82 | 86 |
| Housing starts (thousands) | 586 | 612 | 784 | 930 | 1,004 |
| Light vehicle sales (thousands)[1] | 8,620 | 9,760 | 11,200 | 12,200 | 13,200 |
| Highway construction, value, put in place (billion dollars) | 82 | 80 | 80 | 81 | 83 |

[e]Estimated.

[1]Excludes imports.

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

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 27 commodities at 9 locations in the United States. In fiscal year 2014, DLA Strategic Materials sold $68 million of excess mineral materials from the NDS. At the end of the fiscal year, mineral materials valued at $1.5 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.

**TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2014[p, 1]**

| State | Value (thousands) | Rank | Percent of U.S. total | Principal minerals, in order of value |
|---|---|---|---|---|
| Alabama | $1,080,000 | 24 | 1.39 | Cement (portland), stone (crushed), lime, sand and gravel (construction), cement (masonry). |
| Alaska | 3,510,000 | 7 | 4.52 | Zinc, gold, lead, silver, sand and gravel (construction). |
| Arizona | 8,060,000 | 1 | 10.38 | Copper, molybdenum concentrates, sand and gravel (construction), cement (portland), stone (crushed). |
| Arkansas | 1,030,000 | 26 | 1.33 | Cement (portland), stone (crushed), bromine, sand and gravel (industrial), sand and gravel (construction). |
| California | 3,510,000 | 6 | 4.53 | Sand and gravel (construction), cement (portland), boron minerals, stone (crushed), gold. |
| Colorado | 2,320,000 | 12 | 2.99 | Molybdenum concentrates, sand and gravel (construction), cement (portland), gold, stone (crushed). |
| Connecticut[2] | 202,000 | 43 | 0.26 | Stone (crushed), sand and gravel (construction), clays (common), gemstones (natural). |
| Delaware[2] | 14,400 | 50 | 0.02 | Sand and gravel (construction), magnesium compounds, stone (crushed), gemstones (natural). |
| Florida | 2,990,000 | 8 | 3.86 | Phosphate rock, stone (crushed), cement (portland), sand and gravel (construction), cement (masonry). |
| Georgia | 1,600,000 | 15 | 2.06 | Clays (kaolin), stone (crushed), cement (portland), clays (fuller's earth), sand and gravel (construction). |
| Hawaii | 107,000 | 47 | 0.14 | Stone (crushed), sand and gravel (construction), gemstones (natural). |
| Idaho | 1,200,000 | 21 | 1.55 | Molybdenum concentrates, phosphate rock, sand and gravel (construction), silver, lead. |
| Illinois | 1,460,000 | 17 | 1.88 | Sand and gravel (industrial), stone (crushed), sand and gravel (construction), cement (portland), tripoli. |
| Indiana | 818,000 | 30 | 1.05 | Stone (crushed), cement (portland), lime, sand and gravel (construction), cement (masonry). |
| Iowa | 757,000 | 31 | 0.98 | Stone (crushed), cement (portland), sand and gravel (industrial), sand and gravel (construction), lime. |
| Kansas | 1,030,000 | 27 | 1.33 | Helium (Grade–A), cement (portland), salt, stone (crushed), helium (crude). |
| Kentucky | 857,000 | 29 | 1.10 | Stone (crushed), lime, cement (portland), sand and gravel (construction), sand and gravel (industrial). |
| Louisiana[2] | 554,000 | 34 | 0.71 | Salt, sand and gravel (construction), stone (crushed), sand and gravel (industrial), lime. |
| Maine[2] | 95,000 | 48 | 0.12 | Sand and gravel (construction), cement (portland), stone (crushed), stone (dimension), cement (masonry). |
| Maryland[2] | 277,000 | 41 | 0.36 | Cement (portland), stone (crushed), sand and gravel (construction), cement (masonry), stone (dimension). |
| Massachusetts[2] | 293,000 | 39 | 0.38 | Stone (crushed), sand and gravel (construction), stone (dimension), lime, clays (common). |
| Michigan | 2,410,000 | 10 | 3.11 | Iron ore (usable shipped), cement (portland), sand and gravel (construction), stone (crushed), salt. |
| Minnesota[2] | 4,710,000 | 3 | 6.07 | Iron ore (usable shipped), sand and gravel (industrial), sand and gravel (construction), stone (crushed), stone (dimension). |
| Mississippi | 192,000 | 44 | 0.25 | Sand and gravel (construction), stone (crushed), clays (fuller's earth), clays (ball), clays (bentonite). |

See footnotes at end of table.

**TABLE 3.—VALUE OF NONFUEL MINERAL PRODUCTION IN THE UNITED STATES AND PRINCIPAL NONFUEL MINERALS PRODUCED IN 2014[p, 1]—Continued**

| State | Value (thousands) | Rank | Percent of U.S. total | Principal minerals, in order of value |
|---|---|---|---|---|
| Missouri | 2,480,000 | 9 | 3.19 | Cement (portland), stone (crushed), lead, lime, sand and gravel (industrial). |
| Montana | 1,320,000 | 19 | 1.70 | Palladium metal, copper, molybdenum concentrates, platinum metal, gold. |
| Nebraska | 326,000 | 37 | 0.42 | Cement (portland), stone (crushed), sand and gravel (construction), sand and gravel (industrial), lime. |
| Nevada | 7,490,000 | 2 | 9.66 | Gold, copper, silver, lime, diatomite. |
| New Hampshire | 111,000 | 46 | 0.14 | Sand and gravel (construction), stone (crushed), stone (dimension), gemstones (natural). |
| New Jersey[2] | 288,000 | 40 | 0.37 | Stone (crushed), sand and gravel (construction), sand and gravel (industrial), greensand marl, peat. |
| New Mexico | 1,870,000 | 13 | 2.40 | Copper, potash, sand and gravel (construction), molybdenum concentrates, stone (crushed). |
| New York | 1,370,000 | 18 | 1.76 | Salt, stone (crushed), sand and gravel (construction), cement (portland), wollastonite. |
| North Carolina | 1,290,000 | 20 | 1.66 | Stone (crushed), phosphate rock, sand and gravel (construction), sand and gravel (industrial), clays (common). |
| North Dakota[2] | 232,000 | 42 | 0.30 | Sand and gravel (construction), lime, stone (crushed), clays (common), sand and gravel (industrial). |
| Ohio[2] | 1,150,000 | 22 | 1.48 | Stone (crushed), salt, sand and gravel (construction), lime, cement (portland). |
| Oklahoma | 734,000 | 32 | 0.94 | Stone (crushed), cement (portland), sand and gravel (industrial), sand and gravel (construction), helium (Grade–A). |
| Oregon | 357,000 | 36 | 0.46 | Stone (crushed), sand and gravel (construction), cement (portland), diatomite, perlite (crude). |
| Pennsylvania[2] | 1,560,000 | 16 | 2.01 | Stone (crushed), cement (portland), lime, sand and gravel (construction), sand and gravel (industrial). |
| Rhode Island[2] | 69,200 | 49 | 0.09 | Sand and gravel (construction), stone (crushed), sand and gravel (industrial), gemstones (natural). |
| South Carolina[2] | 581,000 | 33 | 0.75 | Cement (portland), stone (crushed), sand and gravel (construction), sand and gravel (industrial), cement (masonry). |
| South Dakota | 311,000 | 38 | 0.40 | Gold, cement (portland), stone (crushed), sand and gravel (construction), lime. |
| Tennessee | 1,070,000 | 25 | 1.38 | Stone (crushed), zinc, cement (portland), sand and gravel (construction), sand and gravel (industrial). |
| Texas | 4,240,000 | 4 | 5.39 | Stone (crushed), cement (portland), sand and gravel (construction), sand and gravel (industrial), salt. |
| Utah | 4,180,000 | 5 | 5.38 | Copper, gold, molybdenum concentrates, magnesium metal, potash. |
| Vermont[2] | 128,000 | 45 | 0.16 | Stone (crushed), sand and gravel (construction), stone (dimension), talc (crude), gemstones (natural). |
| Virginia | 1,110,000 | 23 | 1.43 | Stone (crushed), cement (portland), lime, sand and gravel (construction), sand and gravel (industrial). |
| Washington | 890,000 | 28 | 1.15 | Sand and gravel (construction), stone (crushed), gold, cement (portland), diatomite. |
| West Virginia | 371,000 | 35 | 0.48 | Stone (crushed), cement (portland), lime, sand and gravel (industrial), cement (masonry). |
| Wisconsin[2] | 1,780,000 | 14 | 2.29 | Sand and gravel (industrial), sand and gravel (construction), stone (crushed), lime, stone (dimension). |
| Wyoming | 2,350,000 | 11 | 3.03 | Soda ash, helium (Grade–A), clays (bentonite), sand and gravel (construction), cement (portland). |
| Undistributed | 871,000 | XX | 1.12 | |
| Total | 77,600,000 | XX | 100.00 | |

[p]Preliminary. XX Not applicable.

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

[2]Partial total; excludes values that must be concealed to avoid disclosing company proprietary data. Concealed values included with “Undistributed.”

# MAJOR METAL-PRODUCING AREAS


## SYMBOLS

| | |
|---|---|
| Au | Gold |
| B1 | Copper and molybdenum +/- gold, silver |
| B2 | Copper +/- gold, silver |
| B3 | Lead, zinc +/- copper +/- gold +/- silver |
| B4 | Zinc and silver + lead and gold |
| Be | Beryllium |
| Fe | Iron |
| Mg | Magnesium |
| Mo | Molybdenum |
| Ni | Nickel + copper + cobalt |
| P1 | Silver +/- base metals |
| P2 | Gold and silver |
| P3 | Gold and silver +/- base metals |
| P4 | Platinum and palladium |
| RE | Rare earths |
| W | Tungsten |
| Zn | Zinc |

# MAJOR INDUSTRIAL MINERAL-PRODUCING AREAS—PART I

# MAJOR INDUSTRIAL MINERAL-PRODUCING AREAS—PART II


## SYMBOLS

| | |
|---|---|
| BC | Ball clay |
| Bent | Bentonite |
| Clay | Common clay |
| DS | Dimension stone |
| FC | Fire clay |
| Fel | Feldspar |
| Ful | Fuller's earth |
| IOP | Iron oxide pigments |
| IS | Industrial sand |
| Ka | Kaolin |
| Li | Lithium carbonate |
| Per | Perlite |
| Pum | Pumice and pumicite |

# ABRASIVES (MANUFACTURED)

(Fused aluminum oxide and silicon carbide)
(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 regular-grade fused aluminum oxide had an estimated value of $2 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 million. Bonded and coated abrasive products accounted for most abrasive uses of fused aluminum oxide and silicon carbide.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production,[1] United States and Canada (crude): | | | | | |
| Fused aluminum oxide, regular | 10,000 | 10,000 | 10,000 | 10,000 | 10,000 |
| Silicon carbide | 35,000 | 35,000 | 35,000 | 35,000 | 35,000 |
| Imports for consumption (U.S.): | | | | | |
| Fused aluminum oxide | 185,000 | 223,000 | 231,000 | 184,000 | 150,000 |
| Silicon carbide | 143,000 | 129,000 | 100,000 | 119,000 | 139,000 |
| Exports (U.S.): | | | | | |
| Fused aluminum oxide | 20,000 | 19,900 | 19,100 | 22,000 | 20,000 |
| Silicon carbide | 23,100 | 27,800 | 20,000 | 18,400 | 21,100 |
| Consumption, apparent (U.S.): | | | | | |
| Fused aluminum oxide | NA | NA | NA | NA | NA |
| Silicon carbide | 155,000 | 136,000 | 115,000 | 136,000 | 153,000 |
| Price, value of imports, dollars per ton (U.S.): | | | | | |
| Fused aluminum oxide, regular | 555 | 627 | 560 | 661 | 670 |
| Fused aluminum oxide, high-purity | 1,300 | 1,360 | 1,080 | 1,660 | 1,410 |
| Silicon carbide | 793 | 1,260 | 877 | 638 | 641 |
| Net import reliance[2] as a percentage of apparent consumption (U.S.): | | | | | |
| Fused aluminum oxide | NA | NA | NA | NA | NA |
| Silicon carbide | 77 | 74 | 70 | 74 | 77 |

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

**Import Sources (2010–13):** Fused aluminum oxide, crude: China, 79%; Venezuela, 12%; Canada, 6%; and other, 3%. Fused aluminum oxide, grain: Germany, 19%; Brazil, 18%; Austria, 16%; Canada, 13%; and other, 34%. Silicon carbide, crude: China, 60%; South Africa, 17%; the Netherlands, 7%; Romania, 7%; and other, 9%. Silicon carbide, grain: China, 43%; Brazil, 24%; Russia, 10%; Norway, 7%; and other, 16%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Fused aluminum oxide, crude | 2818.10.1000 | Free. |
| White, pink, ruby artificial corundum, greater than 97.5% fused 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. |

**Depletion Allowance:** None.

**Government Stockpile:** None.

Prepared by **Donald W. Olson [(703) 648–7721, dolson@usgs.gov]**

# ABRASIVES (MANUFACTURED)

**Events, Trends, and Issues:** In 2014, China was the world's leading producer of abrasive fused aluminum oxide and abrasive silicon carbide, with production nearly at capacity. Imports and higher operating costs than in China 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 markets are greatly influenced by activity in the manufacturing sector in the United States. During 2014, these manufacturing sectors included the aerospace, automotive, furniture, housing, and steel industries, all of which experienced increased production. The U.S. abrasive markets also are influenced by economic and technological trends.

**World Production Capacity:**

| | Fused aluminum oxide | | Silicon carbide | |
|---|---|---|---|---|
| | 2013 | 2014[e] | 2013 | 2014[e] |
| United States and Canada | 60,400 | 60,400 | 42,600 | 42,600 |
| 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 | 700,000 | 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 | 25,000 | 25,000 | 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) | 1,190,000 | 1,290,000 | 1,010,000 | 1,010,000 |

**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. NA Not available. — Zero.
[1]Rounded to the nearest 5,000 tons to protect proprietary data.
[2]Defined as imports – exports.

# ALUMINUM[1]

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

**Domestic Production and Use:** In 2014, three companies operated nine primary aluminum smelters operating in six States, primarily east of the Mississippi River; four smelters were closed for the entire year. Two smelters were permanently shut down during 2014. Based on published market prices, the value of primary metal production was $3.97 billion. Aluminum consumption was centered in the East Central United States. Transportation accounted for an estimated 38% of domestic consumption; the remainder was used in packaging, 22%; building, 13%; electrical, 9%; machinery, 8%; consumer durables, 7%; and other, 3%.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production: | | | | | |
| Primary | 1,726 | 1,986 | 2,070 | 1,946 | 1,720 |
| Secondary (from old scrap) | 1,250 | 1,470 | 1,440 | 1,630 | 1,700 |
| Imports for consumption (crude and semimanufactures) | 3,610 | 3,710 | 3,760 | 4,160 | 4,150 |
| Exports, total | 3,040 | 3,420 | 3,480 | 3,390 | 3,260 |
| Consumption, apparent[2] | 3,460 | 3,570 | 3,950 | 4,530 | 5,090 |
| Price, ingot, average U.S. market (spot), cents per pound | 104.4 | 116.1 | 101.0 | 94.2 | 104.6 |
| Stocks: | | | | | |
| Aluminum industry, yearend | 1,010 | 1,060 | 1,140 | 1,130 | 1,100 |
| LME, U.S. warehouses, yearend[3] | 2,230 | 2,360 | 2,120 | 1,950 | 1,200 |
| Employment, number[4] | 29,200 | 30,300 | 31,500 | 30,100 | 29,000 |
| Net import reliance[5] as a percentage of apparent consumption | 14 | 3 | 11 | 21 | 33 |

**Recycling:** In 2014, aluminum recovered from purchased scrap in the United States was about 3.63 million tons, of which about 53% came from new (manufacturing) scrap and 47% from old scrap (discarded aluminum products). Aluminum recovered from old scrap was equivalent to about 33% of apparent consumption.

**Import Sources (2010–13):** Canada, 63%; Russia, 5%; United Arab Emirates, 5%; China, 4%; and other, 23%.

**Tariff:**

| Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Unwrought (in coils) | 7601.10.3000 | 2.6% ad val. |
| Unwrought (other than aluminum alloys) | 7601.10.6000 | Free. |
| Unwrought (billet) | 7601.20.9045 | Free. |
| Waste and scrap | 7602.00.0000 | Free. |

**Depletion Allowance:** Not applicable.[1]

**Government Stockpile:** None.

**Events, Trends, and Issues:** One of the smelters that produced primary aluminum during 2014 was permanently shut down in May, although the owner planned to build a new smelter at the site in Massena, NY. In March, two potlines with a combined capacity of 84,000 tons per year were permanently shut down. One other 42,000-ton-per-year potline at the smelter had been permanently shut down in August 2013. A new smelter was being built at Massena as required by the terms of a power contract; however, construction was suspended on account of market conditions. Another smelter in Hannibal, OH, that was temporarily idled in 2013 during Chapter 10 bankruptcy proceedings was acquired by a new owner in June. In October, the new owner announced the shutdown would be permanent, citing high power costs. In September, a 269,000-ton-per-year smelter in Evansville, IN, temporarily shut down a 54,000-ton-per-year potline after an electrical fire. By November of 2014, domestic smelters operated at about 71% of rated or engineered capacity. World primary aluminum production increased by about 3% in 2014 compared with production in 2013. New capacity built in recent years in China, where production increased by 5%, accounted for most of the increased production.

Import reliance increased in 2014, as an increase in consumption by U.S. manufacturers was supplied by a drawdown of domestic stocks and decreased exports, while primary production declined and imports remained unchanged. Canada, Russia, and the United Arab Emirates accounted for about 73% of total U.S. imports. Total aluminum exports (crude, semimanufactures, and scrap) from the United States decreased by 4% in 2014 compared with those in 2013. Imports of crude aluminum (metal and alloys) in 2014 were 3% lower than the amount imported in 2013, but imports of semimanufactures and scrap were 13% and 3% higher, respectively, than those in 2013.

Prepared by **E. Lee Bray [(703) 648–4979, lbray@usgs.gov]**

# ALUMINUM

The London Metal Exchange (LME) proposed rule changes to increase the allowable outflows of aluminum stored in LME-bonded warehouses. The proposed changes were struck down by a court in the United Kingdom in March, but that ruling was overturned on appeal in October. Aluminum stocks at LME-bonded warehouses in the United States dropped from 1.95 million tons at yearend 2013 to 1.37 million tons by mid-October, and the downward trend was expected to continue through yearend. Global inventories of primary aluminum metal held by LME-bonded warehouses decreased during the year to 4.51 million tons in mid-October from 5.45 million tons at yearend 2013. Despite the decline in LME inventories, world inventories of metal held by producers, as reported by the International Aluminium Institute, increased gradually to about 2.48 million tons at the end of August from about 2.17 million tons at yearend 2013.

The monthly average U.S. market price for primary ingot quoted by Platts Metals Week started the year at $0.959 per pound and generally increased to $0.977 per pound in May. The monthly average price then trended upward at a faster rate to $1.020 per pound in June and $1.116 per pound in September. Prices on the LME generally followed the trend of U.S. market prices. However, the U.S. market price averaged about 23% higher than the LME price from January through September; in 2013, the average annual U.S. market price was 13% higher than that of the LME price. The increase in the U.S. market price premium was attributed to uncertainty about the proposed LME warehouse rules.

**World Smelter Production and Capacity:**

| | Production | | Yearend capacity | |
|---|---|---|---|---|
| | 2013 | 2014[e] | 2013 | 2014[e] |
| United States | 1,946 | 1,720 | 2,700 | 2,330 |
| Argentina | 425 | 425 | 455 | 455 |
| Australia | 1,780 | 1,680 | 1,820 | 1,630 |
| Bahrain | 913 | 930 | 970 | 970 |
| Brazil | 1,300 | 960 | 1,700 | 1,700 |
| Canada | 2,970 | 2,940 | 3,020 | 2,990 |
| China | 22,100 | 23,300 | 32,000 | 32,500 |
| Germany | 492 | 500 | 620 | 620 |
| Iceland | 800 | 810 | 840 | 840 |
| India | 1,700 | 2,100 | 2,580 | 2,890 |
| Mozambique | 570 | 560 | 570 | 570 |
| Norway | 1,100 | 1,200 | 1,230 | 1,230 |
| Qatar | 600 | 610 | 610 | 610 |
| Russia | 3,720 | 3,500 | 4,040 | 4,180 |
| Saudi Arabia | 190 | 500 | 740 | 740 |
| South Africa | 822 | 735 | 810 | 715 |
| United Arab Emirates | 1,860 | 2,400 | 1,900 | 2,400 |
| Other countries | 4,290 | 4,440 | 6,330 | 6,280 |
| World total (rounded) | 47,600 | 49,300 | 62,900 | 63,700 |

**World Resources:** Global resources of bauxite are estimated to be between 55 to 75 billion tons. Domestic resources are generally not suitable for aluminum production and therefore domestic aluminum requirements cannot be met by domestic bauxite resources. Domestic nonbauxitic aluminum resources are abundant and could meet domestic aluminum demand. A process for recovering alumina from clay was being tested in Canada to determine if it would be economically competitive with the processes now used for recovering alumina from bauxite. Processes for using other aluminum-bearing resources have not been proven to be economically competitive with those now used for bauxite. The world reserves for bauxite are sufficient to meet world demand for metal well into the future.

**Substitutes:** Composites can substitute for aluminum in aircraft fuselages and wings. Glass, paper, plastics, and steel can substitute for aluminum in packaging. Magnesium, steel, and titanium can substitute for aluminum in ground transportation and structural 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]Includes aluminum alloy.
[4]Alumina and aluminum production workers (North American Industry Classification System—3313). Source: U.S. Department of Labor, Bureau of Labor Statistics.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.

# ANTIMONY

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

**Domestic Production and Use:** In 2014, no marketable antimony was mined in the United States. A company in Nevada was developing a mine that had the potential to produce antimony. Primary antimony metal and oxide was 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 2014, based on the average New York dealer price, was about $33 million. Recycling supplied only a minor portion of estimated domestic consumption, and the remainder came from imports. The value of antimony consumption in 2014, based on the average New York dealer price, was about $209 million. The estimated domestic distribution of primary antimony consumption was as follows: nonmetal products, including ceramics and glass and rubber products, 42%; flame retardants, 32%; and metal products, including antimonial lead and ammunition, 26%.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine (recoverable antimony) | — | — | — | — | — |
| Smelter: | | | | | |
| Primary | W | W | W | W | W |
| Secondary | 2,630 | 2,860 | 3,050 | 4,400 | 3,500 |
| Imports for consumption, ores and concentrates, oxide, and metal | 26,200 | 23,500 | 22,600 | 24,700 | 22,000 |
| Exports of metal, alloys, oxide, and waste and scrap[1] | 2,540 | 4,170 | 4,710 | 3,980 | 3,500 |
| Consumption, apparent[2] | 26,100 | 22,300 | 21,000 | 25,100 | 22,000 |
| Price, metal, average, cents per pound[3] | 401 | 650 | 565 | 463 | 431 |
| Stocks, yearend | 1,560 | 1,430 | 1,430 | 1,470 | 1,450 |
| Employment, plant, number (yearend)[e] | 27 | 24 | 24 | 24 | 24 |
| Net import reliance[4] as a percentage of apparent consumption | 90 | 87 | 85 | 82 | 84 |

**Recycling:** Traditionally, the bulk of secondary antimony has been recovered at secondary lead smelters as antimonial lead, most of which was generated by, and then consumed by, the lead-acid battery industry. In 2014, 12 secondary lead smelters (with production capacity greater than 10,000 tons per year) operated in the United States.

**Import Sources (2010–13):** Metal: China, 73%; India, 11%; Mexico, 5%; and other, 11%. Ore and concentrate: Italy, 67%; China, 22%; Bolivia, 4%; and other, 7%. Oxide: China, 68%; Belgium, 9%; Bolivia, 8%; Mexico, 6%; Thailand, 5% and other, 4%. Total: China, 73%; Belgium, 7%; Mexico, 6%; Bolivia, 5%; and other, 9%.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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:** U.S. Antimony Corp. (USAC) in Montana processed imported concentrates and oxides to make antimony products, and during the first half of 2014, produced 238 tons of antimony metal, 7% more than during the same period in 2013. USAC was increasing its antimony production capacity in Mexico by acquiring and expanding historically productive antimony mines and reaching supply agreements to acquire feedstock for its expanding mills and smelter. The company's goal was to produce more than 900 tons of antimony metal at its facilities in the United States and Mexico in 2014 compared with about 716 tons produced in 2013.[5]

Prepared by **David E. Guberman [(703) 648–4977, dguberman@usgs.gov]**

# ANTIMONY

In late 2013, a producer that restarted a historically productive antimony mine, about 194 kilometers northeast of Reno, NV, began mining stibnite (antimony trisulfide) ore for upgrade and sale. By late 2014, about 800 tons of raw ore had been produced. In late 2014, the company acquired a 50% interest in a mill in central Nevada that would enable it to process stibnite ore and produce a marketable antimony concentrate.

The price of antimony metal was relatively flat during the first three quarters of 2014, averaging $4.35 per pound in the first quarter and declining to $4.31 per pound during the third quarter. The average price during the first 9 months of 2014 was about 7% less than that during the same period of 2013, and 34% lower than the peak annual price in 2011.

China was the leading global antimony producer. China's Government considered antimony to be one of the protected and strategic minerals, and mine production of antimony was controlled. For 2014, the Ministry of Land and Resources (MLR) cancelled its mine production quota for antimony for the first time since 2009. Owing to antimony price declines during the previous 3 years, it was unclear if the cancellation would lead to an increase in mine production. Some antimony producers in China halted production earlier in 2014 and cited price declines as a contributing factor. The MLR has reportedly refused any exploration or new mining applications related to antimony since 2009. Owing to the mining restrictions and increased smelting capacity, China's imports of antimony concentrates have increased substantially since 2009. China's export quota for antimony and its products was 59,400 tons in 2014, unchanged from that in 2013.

Several new antimony mine projects were being evaluated and developed in Armenia, Australia, Burma, Canada, China, Georgia, Italy, Laos, Russia, South Africa, and Turkey. In Oman, a producer announced plans to construct an antimony smelter that would have the capacity to produce 20,000 tons per year of antimony metal and oxide and was expected to be completed in 2016.

Global antimony consumption was reduced owing to antimony trioxide consumers opting for substitute materials that were less expensive. The flame retardant industry, which was estimated to consume the majority of global primary antimony production, began substituting for antimony trioxide in 2011 following a significant increase in price. Although prices declined from 2012 to 2014, it was unclear if consumers that had substituted other materials for antimony trioxide would switch back.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[6] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | W | W | NA |
| Bolivia | 5,000 | 5,000 | 310,000 |
| Burma | 9,000 | 9,000 | NA |
| China | 120,000 | 125,000 | 950,000 |
| Russia (recoverable) | 7,000 | 7,000 | 350,000 |
| South Africa | 3,100 | 3,100 | 27,000 |
| Tajikistan | 4,700 | 4,700 | 50,000 |
| Other countries | 5,200 | 5,200 | 150,000 |
| World total (rounded) | 154,000 | 160,000 | 1,800,000 |

**World Resources:** U.S. resources of antimony are mainly in Alaska, Idaho, Montana, and Nevada. Principal identified world resources are in 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 widely accepted substitutes as flame retardants. Compounds of chromium, tin, titanium, zinc, and zirconium substitute for antimony chemicals in enamels, paint, and pigments. Combinations of calcium, copper, selenium, sulfur, and tin are commonly used as substitutes for alloys used in lead-acid batteries.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Gross weight, for metal, alloys, waste, and scrap.
[2]Domestic mine production + 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 - exports + adjustments for Government and industry stock changes.
[5]U.S. Antimony Corp., 2014, Antimony, gold and silver, zeolite production information: Thompson Falls, MT, U.S. Antimony Corp. (Accessed October 7, 2014, at http://www.usantimony.com/2013_production.htm.)
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

# ARSENIC

(Data in metric tons of arsenic unless otherwise noted)

**Domestic Production and Use:** Arsenic trioxide and primary arsenic metal have not been produced in the United States since 1985. However, limited quantities of arsenic metal have been recovered from gallium-arsenide (GaAs) semiconductor scrap. 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. 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 by the electronics industry for GaAs semiconductors that are used for solar cells, space research, and telecommunication. Arsenic was also used for germanium-arsenide-selenide specialty optical materials. Indium-gallium-arsenide was used for short-wave infrared technology. The value of arsenic compounds and metal imported domestically in 2013 was estimated to be about $5.9 million.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Imports for consumption: | | | | | |
| Metal | 769 | 628 | 883 | 514 | 650 |
| Compounds | 4,530 | 4,990 | 5,740 | 6,310 | 5,300 |
| Exports, metal[1] | 481 | 705 | 439 | 1,630 | 3,200 |
| Estimated consumption[2] | 5,300 | 5,620 | 6,620 | 6,820 | 5,950 |
| Value, cents per pound, average[3] | | | | | |
| Metal (China) | 72 | 74 | 75 | 72 | 79 |
| Trioxide (Morocco) | 20 | 22 | 24 | 27 | 30 |
| Net import reliance[4] as a percentage of estimated consumption | 100 | 100 | 100 | 100 | 100 |

**Recycling:** Arsenic metal was recycled from GaAs semiconductor manufacturing. Arsenic contained in the process water at wood treatment plants where CCA was used was also recycled. Although electronic circuit boards, relays, and switches may contain arsenic, no arsenic was recovered from them during recycling 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 (2010–13):** Metal: China, 87%; Japan, 11%; and other, 2%. Arsenic trioxide: Morocco, 61%; China (including Hong Kong), 27%; Belgium, 12%; and other, less than 1%.

| **Tariff:** **Item** | **Number** | **Normal Trade Relations 12–31–13** |
|---|---|---|
| Metal | 2804.80.0000 | Free. |
| Acid | 2811.19.1000 | 2.3% ad val. |
| Trioxide | 2811.29.1000 | Free. |
| Sulfide | 2813.90.1000 | Free. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

**Events, Trends, and Issues:** Human health and environmental concerns continued to limit the demand for arsenic compounds. A voluntary ban on the use of CCA wood preservatives in most residential applications, effective yearend 2003, significantly reduced demand in wood preservative applications. Owing to the residential ban, imports of arsenic trioxide declined to an average of 6,900 tons per year gross weight during 2009 to 2013, from an average of almost 28,000 tons per year during 1999 to 2003. Concern over the adverse effects of arsenic from natural and anthropogenic sources in the human food chain has led to numerous studies of arsenic in fruit juices and rice. In July 2013, the U.S. Food and Drug Administration (FDA) issued a proposed action level of 10 parts per billion for inorganic arsenic in apple juice, the same level set by the U.S. Environmental Protection Agency for arsenic in drinking water. . In September 2013, the U.S. FDA released the results of a sampling study of arsenic contained in rice, a crop that is grown in water and that is susceptible to arsenic uptake. Pending further analysis of the risks posed by the contained arsenic, the FDA recommended that consumers vary their grain intake. In November 2014, Consumer Reports published an analysis of FDA data on arsenic in rice-containing food products and an independent analysis of rice samples that indicated significant variability in the arsenic content of rice, depending on type and region of growth.

Prepared by **Daniel L. Edelstein [(703) 648–4978, dedelste@usgs.gov]**

# ARSENIC

Because of toxicity and carcinogenic concerns, the U.S. Geological Survey has been studying the natural occurrence of arsenic in groundwater as part of its National Water Quality Assessment Program. Arsenic in groundwater is largely the result of minerals dissolving from weathered rocks and soils. Information on USGS maps and related studies on arsenic in groundwater may be accessed at http://water.usgs.gov/nawqa/trace/arsenic/index.html.

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 metal 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 gallium-arsenide (GaAs), indium-arsenide, and indium gallium-arsenide semiconductors that were used in biomedical, communications, computer, electronics, and photovoltaic applications. In 2014, global GaAs device demand increased by about 6% to $6.25 billion, primarily owing to a growing wireless infrastructure in Asia, and increased use of feature-rich, application-intensive, third- and fourth-generation “smartphones,” which employ up to 10 times the amount of GaAs as standard cellular handsets. Based on the reported consumption of gallium, about 34 metric tons of arsenic was consumed domestically to produce GaAs integrated circuits and optoelectronic devices in 2014. See the “Gallium” chapter for additional details.

**World Production and Reserves:**

| | Production (arsenic trioxide) 2013 | Production (arsenic trioxide) 2014[e] | Reserves[5] |
|---|---|---|---|
| United States | — | — | |
| Belgium | 1,000 | 1,000 | |
| Chile | 10,000 | 10,000 | Detailed world reserves data are unavailable but thought to be at least 20 times world production. |
| China | 25,000 | 25,000 | |
| Morocco | 7,500 | 8,000 | |
| Russia | 1,500 | 1,500 | |
| Other countries[6] | 200 | 200 | |
| World total (rounded) | 45,200 | 46,000 | |

**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; 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. Global resources of copper and lead contain approximately 11 million tons of arsenic.

**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, steel, plasticized wood scrap, or plastic composite material.

[e]Estimated. — Zero.
[1]Most of the materials reported to the U.S. Census Bureau as arsenic metal exports are probably arsenic-containing compounds and metal.
[2]Estimated to be the same as imports. Previously reported to be equal to net imports.
[3]Calculated from U.S. Census Bureau import data.
[4]Defined as imports.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]Includes Bolivia, Japan, and Portugal. Mexico and Peru were significant producers of arsenic trioxide, but have reported no production in recent years.

# ASBESTOS

(Data in metric tons unless otherwise noted)

**Domestic Production and Use:** Asbestos has not been mined in the United States since 2002 because of the decline in the U.S. asbestos markets associated with health and liabilities issues. The United States is dependent on imports to meet manufacturing needs. Asbestos consumption in the United States was estimated to be 400 tons, based on asbestos imports through July 2014. The chloralkali industry accounted for an estimated 88% of U.S. consumption. The remainder was used in coatings and compounds, plastics, roofing products, and unknown applications.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production (sales), mine | — | — | — | — | — |
| Imports for consumption | 1,040 | 1,180 | 1,610 | 772 | 201 |
| Exports[1] | 171 | 169 | 47 | 27 | — |
| Consumption, estimated | 1,040 | 1,180 | 1,020 | 772 | 400 |
| Price, average value, dollars per ton[2] | 786 | 931 | 1,570 | 1,508 | 1,560 |
| Net import reliance[3] as a percentage of estimated consumption | 100 | 100 | 100 | 100 | 100 |

**Recycling:** None.

**Import Sources (2010–13):** Brazil, 57%; Canada, 42%; and other, 1%.

| **Tariff:** Item | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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.

Prepared by **Robert L. Virta [(703) 648–7726, rvirta@usgs.gov]**

# ASBESTOS

**Events, Trends, and Issues:** Domestic use of asbestos continued to decline from the record high of 803,000 tons in 1973. In 2014, estimated apparent consumption was 400 tons, a level not seen since the 1800s. The decline has occurred because asbestos substitutes, alternative materials, and new technology displaced asbestos from the traditional domestic asbestos markets. The chloralkali industry, currently the leading domestic consumer of asbestos, gained a greater share of the U.S. asbestos market as other uses declined. Use of asbestos by the chloralkali industry, however, may decline as the industry makes greater use of nonasbestos diaphragms and membrane cell technology, both of which do not use asbestos. Globally, asbestos-cement products are expected to be the leading asbestos-based market. World production is likely to remain at approximately 2.0 Mt for the near future because of continued demand for asbestos products in many regions of the world.

In 2014, U.S. imports decreased by 74% and estimated consumption of asbestos decreased by 48%. Consumption decreased because of reduced demand by the chloralkali and other miscellaneous industries in 2014. Imports decreased significantly in 2014 because domestic demand decreased and domestic companies supplemented imported asbestos with asbestos from industry stocks. In 2014, all asbestos imported and used in the United States was chrysotile, sourced from Australia (5%) and Brazil (95%). Imports from Australia were either from stocks or transshipments because Australia no longer mines asbestos. The average unit value of imports increased by 3% in 2014.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[4] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | — | Small |
| Brazil | 307,000 | 291,000 | 11,000,000 |
| China | 420,000 | 400,000 | Large |
| Kazakhstan | 242,000 | 240,000 | Large |
| Russia | 1,050,000 | 1,050,000 | Large |
| Other countries | 340 | 300 | Moderate |
| World total (rounded) | 2,020,000 | 1,980,000 | Large |

**World Resources:** The world has 200 million tons of identified resources of asbestos. U.S. resources are large but 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 considered to be possible asbestos substitutes for products in which the reinforcement properties of fibers were not required. For the chloralkali industry, membrane cell technology is one alternative to asbestos diaphragms.

[e]Estimated. — Zero.
[1]Thought to include nonasbestos materials and reexports.
[2]Average Customs value for U.S. chrysotile imports, all grades combined. Prices for individual commercial products are not published.
[3]Defined as imports – exports.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.

# BARITE

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** In 2014, about 720,000 tons of crude barite was sold or used for grinding. The value of the ground barite was estimated to be $90 million. Most of the production came from four mines in Nevada; a significantly smaller sales volume came from a single mine in Georgia. An estimated 3.42 million tons of barite (from domestic production and imports) was sold by crushers and grinders operating in eight States. Nearly 95% 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 primarily to exploration companies drilling in Colorado, New Mexico, North Dakota, Utah, and Wyoming. Crude barite was shipped to a Canadian grinding mill in Lethbridge, Alberta, which supplied the western Canada drilling mud market. The barite imported to Louisiana and Texas mostly went to offshore drilling operations in the Gulf of Mexico and to onshore drilling operations in Louisiana, Oklahoma, and Texas.

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, and to add weight to rubber mudflaps on trucks and to 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 consumed as liquid is used as a contrast medium in medical x-ray examinations.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013[e] | 2014[e] |
|---|---|---|---|---|---|
| Sold or used, mine | 662 | 710 | 666 | 700 | 720 |
| Imports for consumption | 2,110 | 2,320 | 2,920 | 2,240 | 2,900 |
| Exports | 109 | 98 | 151 | 200 | 200 |
| Consumption, apparent[1] (crude and ground) | 2,660 | 2,930 | 3,430 | 2,740 | 3,420 |
| Consumption[2] (ground and crushed) | 2,570 | 2,910 | 3,310 | 2,700 | 3,400 |
| Estimated price, average value, dollars per ton, f.o.b. mine | 83 | 94 | 107 | 116 | 125 |
| Employment, mine and mill, number[e] | 379 | 461 | 554 | 624 | 625 |
| Net import reliance[3] as a percentage of apparent consumption | 75 | 76 | 81 | 74 | 79 |

**Recycling:** None.

**Import Sources (2010–13):** China, 80%; India, 11%; Morocco, 4%; Mexico, 3%; and other, 2%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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.

Prepared by **Michele E. McRae [(703) 648–7743, mmcrae@usgs.gov]**

# BARITE

**Events, Trends, and Issues:** Because oil and gas drilling is the dominant use of barite in the United States, the count of operating drill rigs exploring for oil and gas is a good barometer of barite consumption or industry stockpiling. During 2014, the number of drill rigs operating in the United States rose steadily—from 1,757 at yearend 2013 to 1,918 in October 2014. Estimated 2014 barite imports increased by more than 29% compared with those of 2013, indicating increased demand for barite in the drilling sector.

The dependency on a few major exporting countries and rising prices has led to increased interest in diversifying barite supply. In the United States, this is evidenced by a notable decrease in barite imports from China. The 4-year average of barite imports from China peaked during the years 2006–09, representing 95% of the total. By the end of 2013, this percentage had dropped to 80%.

Globally, there is ongoing interest in developing new sources of barite. Barite mining projects in various stages of development were underway in Canada, Georgia, Guatemala, Kazakhstan, Liberia, Mexico, Nigeria, Zimbabwe, and possibly in other countries.

**World Mine Production and Reserves:** Reserves data for India were revised based on Government information.

| | Mine production | | Reserves[4] |
|---|---|---|---|
| | 2013[e] | 2014[e] | |
| United States | 700 | 720 | 15,000 |
| China | 4,000 | 4,100 | 100,000 |
| India | 1,740 | 1,600 | 32,000 |
| Iran | 270 | 270 | NA |
| Kazakhstan | 250 | 250 | 85,000 |
| Mexico | 344 | 400 | 7,000 |
| Morocco | 1,000 | 1,000 | 10,000 |
| Pakistan | 118 | 75 | 1,000 |
| Turkey | 250 | 270 | 35,000 |
| Other countries | 558 | 575 | 66,000 |
| World total (rounded) | 9,230 | 9,260 | 350,000 |

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

**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.
[1]Defined as sold or used by domestic mines + imports – exports.
[2]Imported and domestic barite, crushed and ground, sold or used by domestic grinding establishments.
[3]Defined as imports – exports.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.

# BAUXITE AND ALUMINA[1]

(Data in thousand metric dry tons unless otherwise noted)

**Domestic Production and Use:** In 2014, bauxite consumption was estimated to be 9.6 million tons, nearly all of which was imported, worth an estimated 269 million dollars. More than 95% of the bauxite was converted to alumina, and the remaining 5% went to nonmetallurgical products, such as abrasives, chemicals, proppants, and refractories. There were four domestic Bayer process refineries with a combined alumina production capacity of 5.6 million tons per year. Three of the refineries operated throughout the year. One, which was shut down during the fourth quarter of 2013, was restarted by the beginning of 2014 and ramped up to full production during the first half of the year. About 90% of the alumina produced went to primary aluminum smelters and the remaining 10% went to nonmetallurgical products, such as abrasives, ceramics, chemicals, and refractories.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, bauxite, mine | NA | NA | NA | NA | NA |
| Production, alumina, refinery | 3,470 | 3,790 | 4,370 | 4,390 | 4,200 |
| Imports of bauxite for consumption[2] | 9,310 | 10,200 | 11,100 | 10,800 | 9,600 |
| Imports of alumina[3] | 1,720 | 2,160 | 1,790 | 2,050 | 1,700 |
| Exports of bauxite[2] | 54 | 76 | 42 | 21 | 18 |
| Exports of alumina[3] | 1,520 | 1,660 | 1,720 | 2,300 | 2,200 |
| Consumption, apparent, bauxite and alumina (in aluminum equivalents)[4] | 2,580 | 2,250 | 2,870 | 2,380 | 2,300 |
| Price, bauxite, average value U.S. imports (f.a.s.) dollars per ton | 27 | 30 | 28 | 27 | 28 |
| Price, alumina, average value U.S. imports (f.a.s.) dollars per ton | 365 | 413 | 372 | 368 | 370 |
| Stocks, bauxite, industry, yearend[2] | 95 | 272 | 440 | 540 | 600 |
| Net import reliance,[5] bauxite, as a percentage of apparent consumption | 100 | 100 | 100 | 100 | 100 |
| Net import reliance,[5] alumina, as a percentage of apparent consumption | 2 | E | 13 | E | 5 |

**Recycling:** None.

**Import Sources (2010–13):**[6] Bauxite: Jamaica, 45%; Guinea, 24%; Brazil, 22%; Guyana, 4%; and other, 5%. Alumina: Suriname, 34%; Australia, 33%; Brazil, 12%; Jamaica, 10%; and other, 11%. Total: Jamaica, 29%; Brazil, 18%; Guinea, 18%; Australia, 11%; and other, 24%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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 February 2013, the owner of the 540,000-ton-per-year Burnside, LA, alumina refinery filed for chapter 11 bankruptcy protection, citing high power prices, low aluminum prices, high debt levels, and legacy costs. In August 2013, the company shut down 360,000 tons per year of capacity at the refinery and the remaining capacity was shut down in October. In December 2013, the refinery was sold to a new owner and reopened. The refinery was modified to produce chemical-grade alumina with a capacity of 500,000 tons per year. In October 2014, a labor dispute at a 1,600,000-ton-per-year alumina refinery in Corpus Christi, TX, resulted in an employee lockout. Production continued using management employees and temporary workers.

The estimated annual average price (free alongside ship) for U.S. imports for consumption of metallurgical-grade alumina was $369 per ton. During the first 9 months of the year, the price ranged between $350 per ton and $510 per ton. According to production data from the International Aluminium Institute, world alumina production through September 2013 increased slightly compared with that of the same period in 2013.

Prepared by **E. Lee Bray [(703) 648–4979, lbray@usgs.gov]**

# BAUXITE AND ALUMINA

Bauxite prices are generally negotiated through long-term contracts, and a significant portion of bauxite consumed at alumina refineries in the United States was produced at mines owned by the refinery owners. The estimated annual average price (free alongside ship) for U.S. imports for consumption of crude-dry bauxite was $28 per ton.

Global bauxite production decreased by 17% from that of 2013, principally owing to lower production in Indonesia. In response to a Government ban on exporting bauxite and other unprocessed mineral ores that took effect on January 12, 2014, bauxite mines throughout Indonesia shut down and production decreased from 55.7 million tons in 2013 to an estimated 500,000 tons in 2014. The ban was part of a mining law that was instituted in 2009 to increase development of downstream processing facilities in Indonesia. In response, several companies were planning to build alumina refineries in Indonesia, including companies based in China, where the Government was encouraging investment in power-intensive industries in other countries. In anticipation of the export ban, many refineries in China stockpiled imported bauxite in 2013 and bauxite production in China increased in 2014. Stockpiling by alumina refineries in China was attributed for bauxite production in Indonesia increasing to 55.7 million tons in 2013 from 31.4 million tons in 2012. Total imports of bauxite to China from January 2014 through August 2014 were 46% lower than in the same period in 2013, but alumina production through August was 5% higher than in the same period of 2013.

**World Bauxite Mine Production and Reserves:**

| | Mine production | | Reserves[7] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | NA | NA | 20,000 |
| Australia | 81,100 | 81,000 | 6,500,000 |
| Brazil | 32,500 | 32,500 | 2,600,000 |
| China | 46,000 | 47,000 | 830,000 |
| Greece | 2,100 | 2,100 | 600,000 |
| Guinea | 18,800 | 19,300 | 7,400,000 |
| Guyana | 1,710 | 1,800 | 850,000 |
| India | 15,400 | 19,000 | 540,000 |
| Indonesia | 55,700 | 500 | 1,000,000 |
| Jamaica | 9,440 | 9,800 | 2,000,000 |
| Kazakhstan | 5,400 | 5,500 | 160,000 |
| Russia | 5,320 | 5,300 | 200,000 |
| Suriname | 2,700 | 2,700 | 580,000 |
| Venezuela | 2,160 | 2,200 | 320,000 |
| Vietnam | 250 | 1,000 | 2,100,000 |
| Other countries | 4,570 | 4,760 | 2,400,000 |
| World total (rounded) | 283,000 | 234,000 | 28,000,000 |

**World Resources:** Bauxite resources are estimated to be 55 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. However, the vast U.S. and global resources of clay are technically feasible sources of alumina. Other domestic raw materials, such as alunite, anorthosite, coal wastes, and oil shales, offer additional potential alumina sources. Although it would require new plants using different technology, these nonbauxitic materials could satisfy the demand for alumina. Some refineries in China recover alumina from coal ash. Processes for recovering alumina from clay were being tested in Australia and Canada to determine if they would be economically competitive with the processes now used for recovering alumina from bauxite. Processes for using other aluminum-bearing resources have not yet been proven to be economically competitive with those now used for bauxite. Synthetic mullite, produced from kyanite and sillimanite, substitutes for bauxite-based refractories. Although more costly, silicon carbide and alumina-zirconia can substitute for bauxite-based abrasives.

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

[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]Calcined equivalent weights.

[4]The sum of U.S. bauxite production and net import reliance.

[5]Defined as imports – exports + adjustments for Government and industry stock changes (all in aluminum equivalents).

[6]Based on aluminum equivalents.

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

# BERYLLIUM

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

**Domestic Production and Use:** One company in Utah mined bertrandite ore, which it converted, 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 beryllium-copper master alloy, metal, and oxide—some of which was sold. Estimated beryllium consumption of 270 tons was valued at about $121 million, based on the estimated unit value for beryllium in imported beryllium-copper master alloy. Based on sales revenues, 31% of beryllium alloy strip and bulk products was estimated to be used in industrial components and commercial aerospace applications, 20% in consumer electronics applications, 17% in automotive electronics applications, 12% in energy applications, 11% in telecommunications infrastructure applications, 7% in appliance applications, and 2% in defense and medical applications. Based on sales revenues, 55% of beryllium metal and beryllium composite products was estimated to be used in defense and science applications, 25% in industrial components and commercial aerospace applications, 9% in telecommunications infrastructure applications, 6% in medical applications, and 5% in other applications.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, mine shipments | 180 | 235 | 225 | 235 | 240 |
| Imports for consumption[1] | 271 | 92 | 100 | 57 | 62 |
| Exports[2] | 39 | 21 | 55 | 35 | 28 |
| Government stockpile releases[3] | 29 | 22 | ([4]) | 10 | ([4]) |
| Consumption: | | | | | |
| Apparent[5] | 456 | 333 | 265 | 262 | 270 |
| Reported, ore | 200 | 250 | 220 | 250 | 260 |
| Unit value, annual average, beryllium-copper master alloy, dollars per pound contained beryllium[6] | 228 | 203 | 204 | 208 | 204 |
| Stocks, ore, consumer, yearend | 15 | 10 | 15 | 20 | 25 |
| Net import reliance[7] as a percentage of apparent consumption | 61 | 29 | 15 | 10 | 11 |

**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, and indicated a 40% recovery rate of its beryllium alloy new and old scrap. Beryllium manufactured from recycled sources requires only 20% of the energy as that of beryllium manufactured from virgin sources.

**Import Sources (2010–13):**[1] Russia, 39%; Kazakhstan, 28%; China, 8%; Japan, 4%; and other, 21%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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: | | |
| 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).

**Government Stockpile:** The Defense Logistics Agency Strategic Materials had a goal of retaining 45 tons of hot-pressed beryllium powder in the National Defense Stockpile.

**Stockpile Status—9–30–14**[8]

| Material | Inventory | Disposal Plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|
| Beryl ore | 1 | — | — |
| Metal | 77 | 16 | — |
| Structured powder | 2 | — | — |

Prepared by **Brian W. Jaskula [(703) 648–4908, bjaskula@usgs.gov]**

# BERYLLIUM

**Events, Trends, and Issues:** Apparent demand for beryllium-based products increased slightly in 2014. During the first 9 months of 2014, the leading U.S. beryllium producer reported the volume of shipments of strip and bulk beryllium-copper alloy products to be slightly higher than those during the first 9 months of 2013. Sales of beryllium-copper alloy products for industrial components and commercial aerospace and telecommunications remained relatively unchanged from sales in the first 9 months of 2013, while sales for consumer electronics, energy, and beryllium hydroxide were greater. Sales of beryllium-copper alloy products for automotive electronics were lower. Sales of beryllium metal and beryllium composite products increased about 19% during the first 9 months of 2014 from those in the same period of 2013, with sales for medical and science uses up approximately 24% and 15%, respectively. Sales of beryllium metal and beryllium composite products for the largest application, defense, remained relatively unchanged.

The leading U.S. beryllium producer increased beryllium hydroxide production capacity at its operation in Delta, UT. The company anticipated that global demand for beryllium would exceed production during the next 3 years and global inventories would be drawn down.

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 | | Reserves[9] |
|---|---|---|---|
| | 2013[e] | 2014[e] | |
| United States | 235 | 240 | The United States has very little beryl that can be economically handsorted from pegmatite deposits. The Spor Mountain area in Utah, an epithermal deposit, contains a large bertrandite resource, which was being mined. Proven bertrandite reserves in Utah total about 15,000 tons of contained beryllium. World beryllium reserves are not available. |
| China | 20 | 20 | |
| Mozambique | 6 | 6 | |
| Other countries | 1 | 1 | |
| World total (rounded) | 260 | 270 | |

**World Resources:** World identified resources of beryllium have been estimated to be more than 80,000 tons. About 65% of these resources is in nonpegmatite deposits in the United States—the Gold Hill and Spor Mountain areas in Utah and the Seward Peninsula in Alaska 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.
[1]Includes estimated beryllium content of imported ores and concentrates, oxide and hydroxide, unwrought metal (including powders), beryllium articles, waste and scrap, and beryllium-copper master alloy.
[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]Less than ½ unit.
[5]The sum of U.S. mine shipments and net import reliance.
[6]Calculated from gross weight and customs value of imports; beryllium content estimated to be 4%.
[7]Defined as imports – exports + adjustments for Government and industry stock changes.
[8]See Appendix B for definitions.
[9]See Appendix C for resource/reserve definitions and information concerning data sources.

# BISMUTH

(Data in metric tons of bismuth content 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. A small amount of bismuth is recycled by some domestic firms. Bismuth is contained in some lead ores mined domestically, but the bismuth-containing residues are not processed domestically and may be exported. In 2014, the value of reported consumption of bismuth was approximately $23 million.

Chemical production accounted for about two thirds of domestic bismuth consumption, principally in pharmaceutical applications. Bismuth use in pharmaceuticals included bismuth salicylate (the active ingredient in over-the-counter stomach remedies) and other bismuth medicinal compounds used to treat burns, intestinal disorders, and stomach ulcers in humans and animals. Other applications of bismuth chemicals and compounds included uses in superconductors and pearlescent pigments for cosmetics and paints. Bismuth has a wide variety of metallurgical applications, including use as a nontoxic replacement for lead in brass, free-machining steels, and solders. Bismuth is used as an additive to enhance metallurgical quality in the foundry industry, as a triggering mechanism for fire sprinklers, and in holding devices for grinding optical lenses.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production: | | | | | |
| Refinery | — | — | — | — | — |
| Secondary (old scrap)[e] | 80 | 80 | 80 | 80 | 80 |
| Imports for consumption, metal | 1,620 | 1,750 | 1,700 | 1,710 | 2,100 |
| Exports, metal, alloys, and scrap | 1,040 | 628 | 764 | 816 | 600 |
| Consumption: | | | | | |
| Reported[e] | 636 | 696 | 647 | 774 | 900 |
| Apparent | 660 | 1,200 | 1,020 | 1,060 | 1,380 |
| Price, average, domestic dealer, dollars per pound | 8.76 | 11.47 | 10.10 | 8.71 | 11.39 |
| Stocks, yearend, consumer | 133 | 138 | 134 | 50 | 250 |
| Net import reliance[1] as a percentage of apparent consumption | 88 | 93 | 93 | 92 | 94 |

**Recycling:** All types of bismuth-containing new and old alloy scrap were recycled and contributed less than 10% of U.S. bismuth consumption, or about 80 tons.

**Import Sources (2010–13):** China, 59%; Belgium, 34%; Peru, 2%; United Kingdom, 2%; and other, 3%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Bismuth and articles thereof, including waste and scrap | 8106.00.0000 | Free. |

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

**Government Stockpile:** None.

**Events, Trends, and Issues:** 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. Another application is the use of a bismuth-tellurium oxide alloy film paste for use in the manufacture of semiconductor devices. Bismuth also was used domestically in the manufacture of ceramic glazes, crystal ware, and pigments, and as an additive to free-machining steels and malleable iron castings. An emerging application is in display panels where lead will be replaced by bismuth metal. Researchers in China developed a low-melting-point bismuth-indium-tin-zinc alloy that allows the liquid alloy to be squeezed through tubes that could be used in the 3D printing of electronic components. The new alloy's low melting point requires little cooling, allowing for faster printing than is currently possible with higher melting point metals currently in use.

Prepared by **Florence C. Katrivanos [(703) 648–6782, fkatrivanos@usgs.gov]**

# BISMUTH

A global increase in bismuth demand in 2014 was likely the result of consumer anticipation of higher prices owing to the creation of China's "rare metals" Fanya Metal Exchange, which began trading in Bismuth in March 2013. Buyers purchased bismuth as Chinese prices rose owing to investment demand on the Fanya Metal Exchange. Fanya has over 100,000 members and, during the first half of 2014, bismuth inventory rose by more than 120% to 11,500 tons. By early November, Fanya warehouses reportedly held about 17,000 tons of bismuth, more than a year's worth of global consumption. Concerns over availability and higher prices may have encouraged stockpiling by U.S. and European consumers. The large increase in the calculated U.S. apparent consumption in 2014 may reflect an increase in unreported domestic inventories, including underestimation of the increase in consumer stocks.

In July, Fortune Minerals Ltd fulfilled all permits allowing it to proceed with building the NICO gold-cobalt-bismuth-copper mine and concentrator in the Northwest Territories, Canada. In Peru, La Oroya Metallurgical complex, which had been shuttered in 2009 owing to financial and environmental problems and restarted zinc and lead operations in 2012, halted operations in May 2014 for a month owing to a shortage of concentrate. Following the announcement that creditors had plans to put the zinc-lead smelter up for sale by December, workers called an indefinite strike over disputed unpaid wages. La Oroya complex had been a significant producer of bismuth.

The U.S. domestic dealer price of bismuth, which had trended upward in 2013, started 2014 at $9.30 per pound, increased steadily throughout the year, and ended October at $12.67 per pound. In 2014, the estimated average price of bismuth was about 31% higher than that in 2013. Industry analysts attributed the sharp increase in price to the rise in inventory on the Fanya Metal Exchange that has tightened supply and encouraged consumer buying in anticipation of higher prices.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[2] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | — | — |
| Bolivia | 10 | 10 | 10,000 |
| Canada | 35 | 35 | 5,000 |
| China | 7,500 | 7,600 | 240,000 |
| Mexico | 824 | 824 | 10,000 |
| Russia | 40 | 40 | NA |
| Other countries | — | — | 50,000 |
| World total (rounded) | 8,400 | 8,500 | 320,000 |

**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 based on bismuth content of lead resources because bismuth production is most often a byproduct of processing lead ores; in China, bismuth production is a byproduct 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 that produced bismuth from bismuth ore.

**Substitutes:** Bismuth 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 imports – exports + adjustments for Government and industry stock changes.
[2]See Appendix C for resource/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 2014, and most of the boron products consumed in the United States were manufactured domestically. To avoid disclosing company proprietary data, U.S. boron production and consumption were withheld. The leading boron producer mined borate ores containing kernite, tincal, and ulexite by open pit methods and operated associated compound plants. The kernite was used for boric acid production, tincal was used as a feedstock for sodium borate production, 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 2014, the glass and ceramics industries remained the leading domestic users of boron products, consuming an estimated 80% of total borates consumption. Boron also was used as a component in abrasives, cleaning products, insecticides, and in the production of semiconductors.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production | W | W | W | W | W |
| Imports for consumption, gross weight: | | | | | |
| Borax | ([1]) | 2 | 2 | 2 | 2 |
| Boric acid | 50 | 57 | 55 | 53 | 63 |
| Colemanite | 50 | 20 | 28 | 5 | 41 |
| Ulexite | 1 | 5 | 12 | 13 | 13 |
| Exports, gross weight: | | | | | |
| Boric acid | 264 | 235 | 190 | 232 | 215 |
| Refined sodium borates | 423 | 492 | 457 | 514 | 631 |
| Consumption: | | | | | |
| Apparent | W | W | W | W | W |
| Reported | W | W | W | W | W |
| Price, average value of mineral imports at port of exportation, dollars per ton | 485 | 579 | 569 | 615 | 630 |
| Employment, number | 1,220 | 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 (2010–13):** Borates: Turkey, 81%; China, 3%; Argentina, 3%; Austria, 2%; and other, 11%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Natural borates: | | |
| Sodium | 2528.00.0005 | Free. |
| Calcium | 2528.00.0010 | Free. |
| Other | 2528.00.0050 | Free. |
| Boric acids | 2810.00.0000 | 1.5% ad val. |
| Borates: | | |
| Refined borax: | | |
| Anhydrous | 2840.11.0000 | 0.3% ad val. |
| Other | 2840.19.0000 | 0.1% ad val. |
| Other | 2840.20.0000 | 3.7% ad val. |
| Perborates: | | |
| Sodium | 2840.30.0010 | 3.7% ad val. |
| Other | 2840.30.0050 | 3.7% ad val. |

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

**Government Stockpile:** None.

Prepared by **Robert D. Crangle, Jr. [(703) 648–6410, rcrangle@usgs.gov]**

# BORON

**Events, Trends, and Issues:** Elemental boron is a metalloid that has 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 were 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 the world's supply is consumed in ceramics, detergents, fertilizer, and glass.

Consumption of borates is expected to increase in 2014 and the coming years, spurred by demand in the Asian and South American agricultural, ceramic, and glass markets. Demand for borates was expected to shift slightly away from detergents and soaps toward glass and ceramics.

Canada, China, Korea, Malaysia, and The Netherlands are the countries that imported the largest quantities of mined borates from the United States in 2014. 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 increase 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 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:**

| | Production—All forms[3] | | Reserves[4] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | W | W | 40,000 |
| Argentina | 500 | 500 | 2,000 |
| Bolivia | 150 | 150 | NA |
| Chile | 581 | 580 | 35,000 |
| China | 160 | 165 | 32,000 |
| Kazakhstan | 30 | 30 | NA |
| Peru | 100 | 220 | 4,000 |
| Russia | 250 | 300 | 40,000 |
| Turkey | 1,770 | 1,770 | 60,000 |
| World total (rounded) | [5]3,540 | [5]3,720 | 210,000 |

**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 Turkish deposits are colemanite. Small deposits are being mined in South America. 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, enamel, 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.
[1]Less than ½ unit.
[2]Defined as imports – exports.
[3]Gross weight of ore in thousand metric tons.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.
[5]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 accounted for about one-third of world production capacity.

Primary uses of bromine compounds are in flame retardants, drilling fluids, brominated pesticides (mostly methyl bromide), and water treatment. Bromine also is used in the manufacture of dyes, insect repellents, perfumes, pharmaceuticals, and photographic chemicals. Other bromine compounds are used in a variety of applications, including chemical synthesis, control of mercury emissions from coal-fired powerplants, and paper manufacturing.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production | W | W | W | W | W |
| Imports for consumption, elemental bromine and compounds[1] | 45,400 | 47,300 | 53,600 | 36,300 | 50,000 |
| Exports, elemental bromine and compounds | 8,150 | 7,150 | 6,430 | 7,970 | 7,100 |
| Consumption, apparent | W | W | W | W | W |
| Employment, number[e] | 950 | 950 | 950 | 950 | 950 |
| Net import reliance[2] as a percentage of apparent consumption | <25 | <25 | <25 | <25 | <25 |

**Recycling:** Some bromide solutions were recycled to obtain elemental bromine and to prevent the solutions from being disposed of as hazardous waste. Hydrogen bromide is emitted as a byproduct in many organic reactions. This byproduct waste is recycled with virgin bromine brines and is a major source of bromine production. Plastics containing bromine flame retardants can be incinerated as solid organic waste, and the bromine can be recovered. This recycled bromine is not included in the virgin bromine production reported to the U.S. Geological Survey by companies but is included in data collected by the U.S. Census Bureau.

**Import Sources (2010–13):** Israel, 81%; China, 9%; Germany, 4%; and other, 6%.

| **Tariff:** **Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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. |
| Other bromides and bromide oxides | 2827.59.5100 | 3.6% ad val. |
| 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. |
| Bromochloromethane | 2903.79.1000 | 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.

Prepared by **Joyce A. Ober [Contact Emily K. Schnebele, (703) 648–4945, eschnebele@usgs.gov]**

# BROMINE

**Events, Trends, and Issues:** The United States maintained its position as one of the leading bromine producers in the world. U.S. imports of bromine compounds increased in 2014 in response to increased domestic demand. China, Israel, and Jordan are also major producers of elemental bromine.

U.S. companies did not announce prices for bromine and bromine compounds in 2014, and domestic prices were thought to have remained relatively stable. Trade publications reported that U.S. bromine prices ranged from about $3,500 to $3,900 per ton during the year. The bromine company in Israel announced price increases of about 20% near yearend. In addition to increased bromine prices, prompted by new tax proposals in Israel, the bromine company announced workforce reductions to decrease operating costs. Although the cutbacks were not targeted at bromine facilities, workers protested the cutbacks by disrupting bromine operations.

The leading use of bromine is in flame retardants; this use, however, is in decline because of the environmental considerations and potential health effects related to specific bromine flame-retardant compounds. In 2014, one U.S. bromine chemical producer and its counterpart from Israel announced a collaborative effort to produce a polymeric flame retardant to replace hexabromocyclododecane, which has been the leading flame retardant in some polystyrene foam applications, but was being phased out in the European Union (EU), Japan, and other countries. The joint venture will operate flame retardant plants in Israel and the Netherlands.

The use of bromine to mitigate mercury emissions at powerplants continued to expand. 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. Other growth markets included oilfield chemicals, which use bromine brines in offshore deep-water drilling applications.

**World Production and Reserves:**

| | Production | | Reserves[3] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | W | W | 11,000,000 |
| Azerbaijan | 3,500 | 3,500 | 300,000 |
| China | 110,000 | 110,000 | NA |
| Germany | 1,500 | 1,500 | NA |
| India | 1,700 | 1,700 | NA |
| Israel | 172,000 | 180,000 | NA |
| Japan | 30,000 | 30,000 | NA |
| Jordan | 80,000 | 80,000 | NA |
| Turkmenistan | 500 | 500 | 700,000 |
| Ukraine | 4,100 | 4,100 | NA |
| World total (rounded) | [4]403,000 | [4]411,000 | Large |

**World Resources:** Bromine is found principally in seawater, evaporitic (salt) lakes, and underground brines associated with petroleum deposits. In the Middle East, the Dead Sea 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 and gas well completion and packer applications. Because plastics have a low ignition temperature, alumina, magnesium hydroxide, organic chlorine compounds, and phosphorus compounds can be substituted for bromine as fire retardants in some uses. Bromine compounds and bromine acting as a synergist are used as fire retardants in plastics, such as those found in electronics.

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

# CADMIUM

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

**Domestic Production and Use:** Three companies in the United States produced refined cadmium in 2014. One company, operating in Tennessee, recovered primary refined cadmium as a byproduct of zinc leaching from roasted sulfide concentrates. The other two companies, operating in Ohio and Pennsylvania, recovered secondary cadmium metal from spent nickel-cadmium (NiCd) batteries and other cadmium-bearing scrap. Domestic production and consumption of cadmium from 2011 to 2014 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:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, refined[1] | 637 | W | W | W | W |
| Imports for consumption: | | | | | |
| Unwrought cadmium and powders | 216 | 201 | 170 | 284 | 100 |
| Wrought cadmium and other articles (gross weight) | 5 | 9 | 21 | 104 | 10 |
| Cadmium waste and scrap (gross weight) | ([2]) | ([2]) | 1 | ([2]) | ([2]) |
| Exports: | | | | | |
| Unwrought cadmium and powders | 75 | 63 | 253 | 131 | 140 |
| Wrought cadmium and other articles (gross weight) | 231 | 204 | 378 | 266 | 100 |
| Cadmium waste and scrap (gross weight) | — | 5 | — | 20 | — |
| Consumption of metal, apparent[3] | 703 | W | W | W | W |
| Price, metal, annual average,[4] dollars per kilogram | 3.90 | 2.76 | 2.03 | 1.92 | 1.94 |
| Stocks, yearend, producer and distributor | 102 | W | W | W | W |
| Net import reliance[5] as a percentage of apparent consumption | 9% | <25% | E | <25% | E |

**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 (EAF). The amount of cadmium recovered from secondary sources in 2014 was withheld to avoid disclosing company proprietary data.

**Import Sources (2010–13):**[6] Canada, 25%; Australia, 20%; Mexico, 14%; China, 11%; and other, 30%.

| **Tariff:** Item | Number | Normal Trade Relations[7] 12–31–14 |
|---|---|---|
| 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.

**Events, Trends, and Issues:** Most of the world's primary cadmium metal was produced in Asia. The leading global producers were China, the Republic of Korea, and Japan. Secondary production accounted for about 20% of global production.

Cadmium was primarily consumed in China, Belgium, and Japan. NiCd battery production accounted for more than 80% of global cadmium consumption, and the remainder was used, in order of descending consumption, in pigments, coatings and plating, stabilizers for plastics, nonferrous alloys, and other specialized uses (including photovoltaic devices). The share of cadmium consumed globally for NiCd battery production has been increasing, while the shares for the traditional end uses of cadmium—specifically coatings, pigments, and stabilizers—have gradually decreased owing to environmental and health concerns.

Prepared by **Amy C. Tolcin [(703) 648–4940, atolcin@usgs.gov]**

# CADMIUM

The Platts U.S. market price for 99.95%-purity cadmium metal remained level during the first three quarters of 2014, averaging $1.94 per kilogram. The Metal Bulletin free market price range for 99.95%-purity cadmium metal began the year at $1.71 to $1.94 per kilogram and decreased through April to $1.65 to $1.87 per kilogram, where it remained through July. The price range then increased through September to reach $1.76 to $1.98 per kilogram.

**World Refinery Production and Reserves:**

| | Refinery production | | Reserves[8] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 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. |
| Australia | 380 | 380 | |
| Bulgaria | 400 | 400 | |
| Canada | 1,400 | 1,270 | |
| China | 7,000 | 7,300 | |
| India | 450 | 450 | |
| Japan | 1,830 | 1,790 | |
| Kazakhstan | 1,200 | 1,200 | |
| Korea, Republic of | 4,000 | 4,090 | |
| Mexico | 1,490 | 1,440 | |
| Netherlands | 560 | 570 | |
| Peru | 695 | 710 | |
| Poland | 400 | 400 | |
| Russia | 1,200 | 1,200 | |
| Other countries | 1,020 | 1,000 | |
| World total (rounded) | [9]22,000 | [9]22,200 | |

**World Resources:** Cadmium is generally recovered from zinc ores and concentrates. Sphalerite, the most economically significant zinc 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 are replacing NiCd batteries in some applications. However, the higher cost of these alternatives restricts their use in less-expensive products. Except where the surface characteristics of a coating are critical (for example, fasteners for aircraft), coatings of zinc 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 polyvinylchloride applications.

[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]Defined as domestic refined production + imports of unwrought metal and metal powders – exports of unwrought metal and metal powders + adjustments for industry stock changes.
[4]Average New York dealer price for 99.95% purity in 5-short-ton lots. Source: Platts Metals Week.
[5]Defined as imports of unwrought metal and metal powders – exports of unwrought metal and metal powders + adjustments for Government and industry stock changes.
[6]Imports for consumption of unwrought metal and metal powders (Tariff no. 8107.20.0000).
[7]No tariff for Australia, Canada, Mexico, and Peru for items shown.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.
[9]Does not include production in Italy and the United States.

# CEMENT

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** Domestic production of cement in 2014 increased to about 80.5 million tons of portland cement and 2.2 million tons of masonry cement; output was from 97 plants in 34 States. Cement also was produced at two plants in Puerto Rico. Production continued to be well below the record level of 99 million tons in 2005, and reflected continued full-time idle status at several plants, underutilized capacity at many others, and plant closures in recent years. Cement sales were markedly higher in 2014, but were about 41 million tons below the record volume in 2005. The overall value of sales was about $8.9 billion. Most of the sales of cement were to make concrete, worth at least $48 billion. As in recent years, about 70% of cement sales went to ready-mixed concrete producers, 11% to concrete product manufacturers, 9% to contractors (mainly road paving), 4% each to oil and gas well drillers and to building materials dealers, and 2% to others. Texas, California, Missouri, Florida, and Michigan were, in descending order, the five leading cement-producing States and accounted for 53% of U.S. production.

| **Salient Statistics—United States:**[1] | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production: | | | | | |
| Portland and masonry cement[2] | 66,447 | 67,895 | 74,151 | 76,804 | 82,700 |
| Clinker | 59,802 | 61,241 | 67,173 | 69,394 | 72,300 |
| Shipments to final customers, includes exports | 71,169 | 73,402 | 79,951 | 83,291 | 89,100 |
| Imports of hydraulic cement for consumption | 6,013 | 5,812 | 6,107 | 6,289 | 7,200 |
| Imports of clinker for consumption | 613 | 606 | 786 | 806 | 720 |
| Exports of hydraulic cement and clinker | 1,178 | 1,414 | 1,749 | 1,670 | 1,300 |
| Consumption, apparent[3] | 71,200 | 72,200 | 77,900 | 81,700 | 89,100 |
| Price, average mill value, dollars per ton | 92.00 | 89.50 | 89.50 | 95.00 | 98.50 |
| Stocks, cement, yearend | 6,180 | 6,270 | 6,920 | 6,580 | 6,100 |
| Employment, mine and mill, number[e] | 12,000 | 11,500 | 10,500 | 10,300 | 10,000 |
| Net import reliance[4] as a percentage of apparent consumption | 8 | 7 | 7 | 7 | 7 |

**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 there is significant recycling of concrete for use as construction aggregate.

**Import Sources (2010–13):**[5] Canada, 51%; Republic of Korea, 18%; China, 8%; Greece, 5%; and other, 18%.

| **Tariff:** **Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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:** Sales of cement continued to increase in 2014 owing to higher spending levels for new residential construction and for nonresidential buildings. Public sector construction spending remained relatively weak, but was expected to gradually increase as property tax revenues to the States continued to increase. Imports of cement increased, but several major cement-dedicated import terminals remained idle. Cement production remained well below capacity levels and some multikiln plants continued to operate only one kiln in 2014. No new plants opened in 2014, although a number of plant upgrades were underway, including conversions of some wet kilns to more energy-efficient dry, precalciner technology. No plant closures were announced during the year. In 2014, two of the world's largest cement companies announced their planned merger; this would create the highest capacity cement company in the world. Although granted in the European Union, approval of the merger had not been given in the United States as of yearend but was anticipated to require the sale of certain U.S. assets, although overlap in cement production capacity by the two companies existed in only one State.

Prepared by **Hendrik G. van Oss [(703) 648–7712, hvanoss@usgs.gov]**

# CEMENT

The manufacture of clinker for cement releases a great deal of carbon dioxide. Carbon dioxide reduction strategies by the cement industry were mainly aimed at reducing emissions per ton of cement product rather than by cement plant. Approaches include installation of more fuel-efficient kilns, partial substitution of noncarbonate sources of calcium oxide in the kiln raw materials, and partial substitution of SCMs, such as pozzolans, for portland cement in the finished cement products and in concrete. Because SCMs do not require the energy-intensive clinker manufacturing (kiln) phase of cement production, their use, and the use of inert additives or extenders, reduces the unit costs and emissions of the cement component of concrete. The ASTM C-595 standard for blended cement allows for the addition of up to 15% limestone in some blends, but widespread use of limestone addition was still not evident in 2014. Research continued toward developing cements that require less energy to manufacture than portland cement, and (or) that use raw materials that result in reduced emissions.

The cement industry was granted a delay until 2015 in the implementation of the 2010 National Emissions Standards for Hazardous Air Pollutants (NESHAP) protocol for cement plants. The protocol would significantly lower the acceptable emissions levels of mercury and certain other pollutants. Mercury scrubbing technology was being installed at a number of plants, but it remained unclear how many plants could afford the technology. The mercury limits were expected to make it difficult for cement plants to continue to burn fly ash as a raw material for clinker manufacture.

**World Production and Capacity:**

| | Cement production | | Clinker capacity | |
|---|---|---|---|---|
| | 2013[e] | 2014[e] | 2013[e] | 2014[e] |
| United States (includes Puerto Rico) | 77,400 | 83,300 | 104,300 | 104,300 |
| Brazil | 70,000 | 72,000 | 60,000 | 60,000 |
| China | 2,420,000 | 2,500,000 | 1,900,000 | 2,000,000 |
| Egypt | 50,000 | 50,000 | 46,000 | 46,000 |
| Germany | 31,300 | 31,000 | 31,000 | 31,000 |
| India | 280,000 | 280,000 | 280,000 | 280,000 |
| Indonesia | 56,000 | 60,000 | 51,000 | 50,000 |
| Iran | 72,000 | 75,000 | 80,000 | 80,000 |
| Italy | 22,000 | 22,000 | 46,000 | 46,000 |
| Japan | 57,400 | 58,000 | 55,000 | 55,000 |
| Korea, Republic of | 47,300 | 47,700 | 50,000 | 50,000 |
| Mexico | 34,600 | 35,000 | 42,000 | 42,000 |
| Pakistan | 31,000 | 32,000 | 43,400 | 44,000 |
| Russia | 66,400 | 69,000 | 80,000 | 80,000 |
| Saudi Arabia | 57,000 | 63,000 | 55,000 | 55,000 |
| Thailand | 42,000 | 42,000 | 50,000 | 50,000 |
| Turkey | 71,300 | 75,000 | 68,500 | 69,000 |
| Vietnam | 58,000 | 60,000 | 80,000 | 80,000 |
| Other countries (rounded) | 536,000 | 525,000 | 348,000 | 349,000 |
| World total (rounded) | 4,080,000 | 4,180,000 | 3,470,000 | 3,570,000 |

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

**Substitutes:** Most portland cement is used in making concrete or mortars and, as such, competes in the construction sector with concrete substitutes, such as aluminum, asphalt, clay brick, rammed earth, fiberglass, glass, 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 the lime released by the hydration of portland cement. Where not constrained in supply, 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.

[2]Includes cement made from imported clinker.

[3]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.

# CESIUM

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

**Domestic Production and Use:** In 2014, there was no domestic production of cesium and the United States was 100% import reliant for cesium minerals. The principal cesium mineral, pollucite, is known to occur in pegmatites in Alaska, Maine, and South Dakota. The United States sources the majority of pollucite from the largest known North American deposit at Bernic Lake, Manitoba, Canada.

Cesium, in the form of chemical compounds, is the principal end use of cesium ore. By gross weight, formate brines for high-pressure/high-temperature oil and gas drilling 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, cesium metal production, high-temperature solders, isopycnic centrifugation, nuclear medicine, repellents, specialty glasses, and spectrometers. Cesium carbonate is used in the N-alkylation of 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 scintillators.

Cesium isotopes, which can be obtained as a fission by-product 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 a 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.

Fission byproducts cesium-131 and cesium-137 are used primarily to treat cancer. One company in Richland, WA, produced a range of cesium-131 medical products for treatment of various cancers. Cesium-137 also is widely used in industrial gauges, in mining and geophysical instruments, and for sterilization of food, sewage, and surgical equipment. Cesium can be used in metallurgy to remove gases and other impurities, and as a "getting" agent in vacuum tubes.

**Salient Statistics—United States:** Consumption, import, and export data for cesium have not been available since the late 1980s. Because cesium metal is not traded in commercial quantities, a market price is unavailable. Only a few thousand kilograms of cesium are consumed in the United States every year. In 2014, one company offered 1-gram ampoules of 99.8% (metal basis) cesium for $59.70 each and 99.98% (metal basis) cesium for $73.40, an increase of 3.9% and 4.1%, respectively, from those of 2013. The price for 50 grams of 99.8% (metals basis) cesium was $736.00, and 100 grams of 99.98% (metal basis) cesium was priced at $2,020.00, an increase of 3.8% and 3.9%, respectively, from those of 2013 for both products.

**Recycling:** Cesium formate brines are typically rented by oil and gas exploration clients. After completion of the well, the used cesium formate is returned and reprocessed for subsequent drilling operations. Approximately 85% of the cesium formate can be retrieved and recycled for further use. Cesium formate production from Canada was estimated at 5,630 tons per year, to include 3,890 tons of cesium from 17,300 tons of pollucite ore, with a recovery rate of 85%.

**Import Sources (2010–13):** Canada is the chief source of pollucite concentrate imported by the United States.

**Tariff:**

| Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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.

Prepared by **Christopher A. Tuck [(703) 648–4912, ctuck@usgs.gov]**

# CESIUM

**Events, Trends, and Issues:** Domestic cesium occurrences will likely remain uneconomic unless market conditions change. Cesium can be produced as a byproduct of lithium production. 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.

As reported in 2014, one underground mining operation at Bernic Lake, Manitoba, Canada, experienced a fall of ground in early 2013 following a similar event in 2010. Monitoring equipment was installed at the site that indicated good structural stability; however, the mines stability may be at risk for near-term deterioration and flooding. Development alternatives were assessed for continuity of operations. The company increased production to assure cesium ore inventory would meet customer needs in the event they would be unable to continue mining or unwilling to incur costs needed to further develop the mine. In Argentina, one company began bulk sampling and drilling to determine resource estimates for a cesium and rubidium deposit. The deposit underwent prefeasibility studies and expected reserve estimates to be complete by yearend 2014. Initial studies indicated a cesium to rubidium ratio of 8:1.

In 2014, one company in Richland, WA, announced improved results and FDA approval for using cesium-131 seeds for the treatment of gynecologic cancers, instead of gold-198, owing to its blend of high energy and 9.7-day half-life. Another company, in Austin, TX, was awarded a $1.1 million grant by the Department of Energy for the development and marketing of a Self-Contained Blood Irradiator, a replacement for radioactive isotope irradiators that contain cesium-137. A policy statement from the Nuclear Regulatory Commission encouraged the replacement of cesium-137 chloride in devices, as well as a long-term strategy for its storage and disposal, owing to the potential for use in a radiological dispersal device.

In April, the National Institute of Standards and Technology launched the NIST-F2, a new type of cesium fountain clock that utilizes a colder environment, tripling the accuracy over its predecessor, NIST-F1. The NIST-F2 became the world's most accurate time standard and will now serve as the U.S. civilian time and frequency standard. The agency utilizes over 300 atomic clocks across the world to establish the Coordinated Universal Time (UTC), the international standard of time. In September, Kazakhstan's National Security Committee reported a container of cesium, most likely originating from a medical facility, had gone missing in the western region of Kazahkstan. A vanadosilicate was developed in Seoul, South Korea, that can remove cesium-137 from contaminated coolant water, liquid nuclear waste, and contaminated water sources more effectively than conventional sorbents.

**World Mine Production and Reserves:** Pollucite, mainly formed 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% $Cs_2O$. 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 pollucite, with pre-mining average $Cs_2O$ grades of 23.3%. Sites near Lake Ontario have identified cesium resources; exploration of those deposits began in the last quarter of 2013. Zimbabwe and Namibia produced cesium in small quantities as a byproduct of lithium mining operations.

| | Reserves[1] |
|---|---|
| Canada | 120,000 |
| Namibia | 30,000 |
| Zimbabwe | 60,000 |
| Other countries | NA |
| World total (rounded) | 210,000 |

**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. 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 pollucite, lepidolite, and geyserite, 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.

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

# CHROMIUM

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

**Domestic Production and Use:** In 2014, the United States was expected to consume about 5% of world chromite ore production in various forms of imported materials, such as chromite ore, chromium chemicals, chromium ferroalloys, chromium metal, and stainless steel. One U.S. company mined chromite ore in Oregon from which it produced foundry sand. Imported chromite ore was consumed by one chemical firm to produce chromium chemicals. One company produced chromium metal. Stainless- and heat-resisting-steel producers were the leading consumers of ferrochromium. Stainless steels and superalloys require chromium. The value of chromium material consumption in 2013 was $687 million as measured by the value of net imports, excluding stainless steel, and was expected to be about $690 million in 2014.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine | — | — | NA | NA | NA |
| Recycling[1] | 144 | 147 | 146 | 150 | 155 |
| Imports for consumption | 499 | 531 | 554 | 475 | 631 |
| Exports | 274 | 232 | 234 | 235 | 226 |
| Government stockpile releases | 15 | 4 | 4 | 10 | 10 |
| Consumption: | | | | | |
| Reported (includes recycling) | 396 | 400 | 401 | 402 | 414 |
| Apparent[2] (includes recycling) | 384 | 450 | 471 | 400 | 560 |
| Unit value, average annual import (dollars per metric ton): | | | | | |
| Chromite ore (gross quantity) | 212 | 355 | 392 | 310 | 223 |
| Ferrochromium (chromium content) | 2,564 | 2,603 | 2,362 | 2,156 | 2,190 |
| Chromium metal (gross quantity) | 11,323 | 14,090 | 13,333 | 11,147 | 10,866 |
| Stocks, yearend, held by U.S. consumers | 7 | 8 | 8 | 8 | 8 |
| Net import reliance[3] as a percentage of apparent consumption | 63 | 67 | 69 | 63 | 72 |

**Recycling:** In 2014, recycled chromium (contained in reported stainless steel scrap receipts) accounted for 36% of apparent consumption.

**Import Sources (2010–13):** Chromite mineral: South Africa, 100%. Chromium-containing scrap: Canada, 54%; Mexico, 41%; and other, 5%. Chromium primary metal: South Africa, 31%; Kazakhstan, 19%; Russia, 11%; China, 5%; and other 34%. Total imports: South Africa, 38%; Kazakhstan, 16%; Russia, 9%; Mexico, 6%; and other, 31%.

| **Tariff:**[4] **Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| Ore and concentrate | 2610.00.0000 | Free. |
| Ferrochromium: | | |
| Carbon more than 4% | 7202.41.0000 | 1.9% ad val. |
| Carbon more than 3% | 7202.49.1000 | 1.9% ad val. |
| Other: | | |
| Carbon more than 0.5% | 7202.49.5010 | 3.1% ad val. |
| Other | 7202.49.5090 | 3.1% ad val. |
| Ferrochromium silicon | 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).

**Government Stockpile:** For FY 2015, the Defense Logistics Agency Strategic Materials announced maximum disposal limits for chromium materials of about 21,300 t of ferrochromium and 136 t of chromium metal.

Prepared by **John F. Papp [(703) 648–4963, jpapp@usgs.gov]**

# CHROMIUM

**Stockpile Status—9–30–14[5]**

| Material | Inventory | Disposal Plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|
| Ferrochromium: | | | |
| High-carbon | 74.9 | [6]88.0 | 11.3 |
| Low-carbon | 37.0 | — | 8.15 |
| Chromium metal | 3.96 | 0.5 | 0.13 |

**Events, Trends, and Issues:** China is the leading chromium-consuming and ferrochromium-producing country and the leading stainless steel producer. Chromium is consumed in the form of ferrochromium to produce stainless steel. South Africa was the leading chromite ore and a leading ferrochromium producer upon whom world stainless steel producers depend directly or indirectly for chromium supply. South Africa's electrical power generating group declared an emergency because of the country's constrained electrical power supply. Ferrochromium production is electrical energy intensive, so constrained electrical power supply means constrained ferrochromium production. DLA Strategic Materials planned to continue selling ferrochromium in fiscal year 2015 until it reaches its limit; however, DLA Strategic Materials would need congressional authority to continue sales into the next fiscal year.

**World Mine Production and Reserves:**

| | Mine production[7] | | Reserves[8] |
|---|---|---|---|
| | 2013 | 2014[e] | (shipping grade)[9] |
| United States | NA | NA | 620 |
| India | 2,950 | 3,000 | 54,000 |
| Kazakhstan | 3,700 | 4,000 | 230,000 |
| South Africa | 13,700 | 15,000 | 200,000 |
| Turkey | 3,300 | 2,400 | NA |
| Other countries | 5,150 | 4,600 | NA |
| World total (rounded) | 28,800 | 29,000 | >480,000 |

**World Resources:** World resources are greater than 12 billion tons of shipping-grade chromite, sufficient to meet conceivable demand for centuries. About 95% of the world's chromium resources is geographically concentrated in Kazakhstan and southern Africa; U.S. 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 stainless steel scrap receipts.
[2]Defined as production (from mines and recycling) + imports – exports + adjustments for Government and industry stock changes.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]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.
[5]See Appendix B for definitions.
[6]High-carbon and low-carbon ferrochromium, combined.
[7]Mine production units are thousand metric tons, gross weight, of marketable chromite ore.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.
[9]Reserves units are thousand metric 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:** In 2014, production (sales or use) was estimated to be 24.7 million tons valued at $1.55 billion. Clay and shale production was reported in 37 States. About 160 companies operated approximately 725 clay pits or quarries. The leading 20 firms supplied about 57% of the tonnage and 79% of the value for all types of clay sold or used in the United States. The United States probably accounted for 15% to 25% of the global production of refined clays, excluding common clay and shale. Uses for specific clays were estimated to be as follows: ball clay—39% floor and wall tile, 17% sanitaryware, and 44% other uses; bentonite—26% absorbents, 24% drilling mud, 15% foundry sand bond, 11% iron ore pelletizing, and 24% other uses; common clay—39% brick, 31% cement, 23% lightweight aggregate, and 7% other uses; fire clay—34% heavy clay products and 66% refractory products and other uses; fuller's earth—70% absorbent uses and 30% other uses; and kaolin—47% paper and 53% other uses, including lightweight ceramic proppants, which have become a significant market for kaolin.

In 2014, the United States exported 880,000 tons of bentonite mainly for pet waste absorbent, drilling mud, foundry sand bond, and iron ore pelletizing applications, with Japan being the leading destination. About 2.6 million tons of kaolin were exported mainly as a paper coating and filler, a component in ceramic bodies, and fillers and extenders in paint, plastic, and rubber products, with China being the leading destination. Lesser amounts of ball clay, fire clay, and fuller's earth were exported for ceramic, refractory, and absorbent uses, respectively.

| **Salient Statistics—United States:**[1] | **2010** | **2011** | **2012** | **2013** | **2014**[e] |
|---|---|---|---|---|---|
| Production (sold or used): | | | | | |
| Ball clay | 912 | 886 | 973 | 1,000 | 1,030 |
| Bentonite | 4,600 | 4,990 | 4,980 | 4,350 | 4,660 |
| Common clay | 11,900 | 11,700 | 11,900 | 10,600 | 10,900 |
| Fire clay | 216 | 215 | 183 | 151 | 174 |
| Fuller's earth[2] | 2,050 | 1,950 | 1,980 | 1,990 | 2,070 |
| Kaolin | 5,950 | 5,950 | 5,900 | 5,950 | 5,830 |
| Total[2, 3] | 25,600 | 25,700 | 25,900 | 24,000 | 24,700 |
| Imports for consumption: | | | | | |
| Artificially activated clay and earth | 28 | 31 | 31 | 28 | 23 |
| Kaolin | 510 | 549 | 472 | 468 | 440 |
| Other | 17 | 13 | 21 | 27 | 16 |
| Total[3] | 555 | 593 | 524 | 523 | 480 |
| Exports: | | | | | |
| Ball clay | 45 | 49 | 77 | 52 | 50 |
| Bentonite | 953 | 1,020 | 1,030 | 890 | 880 |
| Fire clay[4] | 404 | 371 | 289 | 268 | 250 |
| Fuller's earth | 100 | 102 | 107 | 86 | 95 |
| Kaolin | 2,470 | 2,490 | 2,450 | 2,540 | 2,580 |
| Clays, not elsewhere classified | 382 | 209 | 315 | 304 | 290 |
| Total[3] | 4,360 | 4,240 | 4,270 | 4,140 | 4,150 |
| Consumption, apparent | 21,800 | 22,100 | 22,200 | 20,400 | 21,000 |
| Price, average, dollars per ton: | | | | | |
| Ball clay | 45 | 46 | 46 | 43 | 43 |
| Bentonite | 58 | 61 | 62 | 65 | 65 |
| Common clay | 12 | 12 | 10 | 12 | 12 |
| Fire clay | 28 | 30 | 27 | 23 | 23 |
| Fuller's earth[2] | 98 | 100 | 92 | 90 | 91 |
| Kaolin | 137 | 143 | 149 | 147 | 150 |
| Employment, number: | | | | | |
| Mine | 828 | 810 | 900 | 820 | 860 |
| Mill | 4,400 | 4,200 | 4,350 | 4,350 | 4,330 |
| Net import reliance[5] as a percentage of apparent consumption | E | E | E | E | E |

**Recycling:** Insignificant.

**Import Sources (2010–13):** Brazil, 83%; Canada, 6%; Mexico, 4%; and other, 7%.

Prepared by **Robert L. Virta [(703) 648–7726, rvirta@usgs.gov]**

# CLAYS

**Tariff:** 

| Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Kaolin and other kaolinitic 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 and fuller's earths | 2508.40.0120 | Free. |
| Other clays | 2508.40.0150 | Free. |
| Chamotte or dina's earth | 2508.70.0000 | Free. |
| Activated clays and 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); and ball clay, bentonite, china clay, sagger clay, and clay used or sold for use dependent on its refractory properties, 14% (Domestic).

**Government Stockpile:** None.

**Events, Trends, and Issues:** Increased commercial and residential housing construction may result in slightly increased sales of common clay for heavy clay products and ball clay for ceramic tile and sanitaryware manufacture. For bentonite, sales increased for drilling mud, foundry sand bond, and civil-engineering applications. Sales of fuller's earth increased slightly, mainly because of a slight increase in sales for pet litters and fluid purification applications. Decreased kaolin sales for paper markets were somewhat balanced by increased sales for ceramic proppants.

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

| | Mine production | | | | | |
|---|---|---|---|---|---|---|
| | Bentonite | | Fuller's earth | | Kaolin | |
| | 2013 | 2014[e] | 2013 | 2014[e] | 2013 | 2014[e] |
| United States (sales) | 4,350 | 4,660 | [2]1,990 | [2]2,070 | 5,950 | 5,830 |
| Brazil (beneficiated) | 513 | 500 | — | — | 2,200 | 1,800 |
| Czech Republic (crude) | 226 | 230 | — | — | 3,110 | 3,110 |
| Germany (sales) | 375 | 350 | — | — | 4,900 | 4,500 |
| Greece (crude) | 1,000 | 1,000 | — | — | — | — |
| Italy | 110 | 100 | 3 | 3 | 640 | 640 |
| Mexico | 618 | 620 | 108 | 100 | 163 | 160 |
| Spain | 115 | 100 | 593 | 590 | 303 | 250 |
| Turkey | 1,100 | 1,100 | — | — | 3,800 | 3,800 |
| Ukraine (crude) | 210 | 180 | — | — | 1,100 | 1,100 |
| United Kingdom (sales) | — | — | — | — | 900 | 900 |
| Uzbekistan (crude) | 25 | 25 | — | — | 7,500 | 7,000 |
| Other countries | 3,360 | 3,300 | 306 | 270 | 9,730 | 11,000 |
| World total (rounded) | 12,000 | 12,200 | [2]3,000 | [2]3,000 | 40,300 | 41,000 |

**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]Excludes Puerto Rico.
[2]Excludes attapulgite.
[3]Data may not add to totals shown because of independent rounding.
[4]Also includes refractory-grade kaolin.
[5]Defined as imports – exports.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

# COBALT

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

**Domestic Production and Use:** A nickel-copper mine in Michigan began production and shipped cobalt-bearing nickel concentrate in late 2014. Most U.S. supply comprised imports and secondary (scrap) materials. The sole U.S. producer of extra-fine cobalt powder, in Pennsylvania, used cemented carbide scrap as feed. Seven companies were known to produce cobalt compounds. About 47% of the cobalt consumed in the United States was used in superalloys, mainly in aircraft gas turbine engines; 9% in cemented carbides for cutting and wear-resistant applications; 17% in various other metallic applications; and 27% in a variety of chemical applications. The total estimated value of cobalt consumed in 2014 was $275 million.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine | — | — | — | — | NA |
| Secondary | 2,000 | 2,210 | 2,160 | 2,160 | 2,200 |
| Imports for consumption | 11,100 | 10,600 | 11,100 | 10,500 | 11,700 |
| Exports | 2,640 | 3,390 | 3,760 | 3,850 | 4,800 |
| Shipments from Government stockpile excesses[1] | -8 | — | — | — | — |
| Consumption: | | | | | |
| Reported (includes secondary) | 8,130 | 9,180 | 8,660 | 8,090 | 8,200 |
| Apparent[2] (includes secondary) | 10,300 | 9,230 | 9,520 | 8,670 | 9,200 |
| Price, average, dollars per pound: | | | | | |
| Spot, cathode[3] | 20.85 | 17.99 | 14.07 | 12.89 | 14.40 |
| London Metal Exchange (LME), cash | XX | 16.01 | 13.06 | 12.26 | 14.00 |
| Stocks, yearend: | | | | | |
| Industry | 880 | 1,040 | 970 | 1,070 | 1,040 |
| LME, U.S. warehouse | 23 | 43 | 51 | 41 | 10 |
| Net import reliance[4] as a percentage of apparent consumption | 81 | 76 | 77 | 75 | 76 |

**Recycling:** In 2014, cobalt contained in purchased scrap represented an estimated 27% of cobalt reported consumption.

**Import Sources (2010–13):** Cobalt contained in metal, oxide, and salts: China, 21%; Norway, 11%; Russia, 10%; Finland, 9%; and other, 49%.

| **Tariff:** Item | **Number** | **Normal Trade Relations[5] 12–31–14** |
|---|---|---|
| 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—9–30–14[6]**

| **Material** | **Inventory** | **Disposal Plan FY 2014** | **Disposals FY 2014** |
|---|---|---|---|
| Cobalt | 301 | — | — |

Prepared by **Kim B. Shedd [(703) 648–4974, kshedd@usgs.gov]**

# COBALT

**Events, Trends, and Issues:** In recent years, global production of refined cobalt has been higher than consumption, resulting in a market surplus and downward pressure on prices. This trend is expected to continue in the near-term as production from new projects and expansions to existing operations add to supply of mined and refined cobalt. China was the world's leading producer of refined cobalt and the 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). In recent years, China has been drawing down significant stocks of cobalt feed that had accumulated from 2009 through 2011.

During the first 6 months of 2014, world availability of refined cobalt (as measured by production) was 10% higher than that of the same period in 2013. China showed a large increase in production of refined cobalt; significant increases in production in Finland, Japan, and Madagascar also contributed to supply. Worldwide cobalt inventories in London Metal Exchange (LME) warehouses decreased to 491 tons at the end of October 2014 from 560 tons at yearend 2013.

**World Mine Production and Reserves:** Reserves for Australia, Brazil, Canada, the United States, and "Other countries" were revised based on company or Government reports.

| | Mine production | | Reserves[7] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | NA | 37,000 |
| Australia | 6,400 | 6,500 | [8]1,100,000 |
| Brazil | 3,000 | 3,000 | 85,000 |
| Canada | 6,920 | 7,000 | 250,000 |
| China | 7,200 | 7,200 | 80,000 |
| Congo (Kinshasa) | 54,000 | 56,000 | 3,400,000 |
| Cuba | 4,200 | 4,200 | 500,000 |
| New Caledonia[9] | 3,190 | 2,800 | 200,000 |
| Philippines | 3,000 | 3,700 | 270,000 |
| Russia | 6,300 | 6,300 | 250,000 |
| South Africa | 3,000 | 3,000 | 32,000 |
| Zambia | 5,200 | 3,100 | 270,000 |
| Other countries | 8,000 | 9,500 | 750,000 |
| World total (rounded) | 110,000 | 112,000 | 7,200,000 |

**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. NA Not available. XX Not applicable. — Zero.
[1]Negative numbers are the result of inventory adjustments.
[2]The sum of U.S. net import reliance and secondary production, as estimated from consumption of purchased scrap.
[3]As reported by Platts Metals Daily (formerly Platts Metals Week).
[4]Defined as imports – exports + adjustments for Government and industry stock changes for refined cobalt.
[5]Tariffs for certain countries and items may be eliminated under special trade agreements.
[6]See Appendix B for definitions.
[7]See Appendix C for resource/reserve definitions and information concerning data sources.
[8]For Australia, Joint Ore Reserves Committee (JORC)-compliant reserves were about 390,000 tons.
[9]Overseas territory of France.

# COPPER

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

**Domestic Production and Use:** In 2014, U.S. mine production of copper increased by 10% to about 1.37 million tons, and was valued at about $9.7 billion. Arizona, Utah, New Mexico, Nevada, and Montana—in descending order of production—accounted for more than 99% of domestic mine production; copper also was recovered in Idaho and Missouri. Twenty-seven mines recovered copper, 17 of which accounted for about 99% of production. Three primary smelters, 3 electrolytic and 4 fire refineries, and 14 electrowinning facilities operated during 2014. Refined copper and scrap were consumed at about 30 brass mills, 15 rod mills, and 500 foundries and miscellaneous consumers. Copper and copper alloys products were used in building construction, 43%; electric and electronic products, 19%; transportation equipment, 19%; consumer and general products, 12%; and industrial machinery and equipment, 7%.[1]

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine | 1,110 | 1,110 | 1,170 | 1,250 | 1,370 |
| Refinery: | | | | | |
| Primary | 1,060 | 992 | 962 | 993 | 1,070 |
| Secondary | 38 | 37 | 39 | 47 | 50 |
| Copper from all old scrap | 143 | 153 | 164 | 180 | 180 |
| Imports for consumption: | | | | | |
| Ores and concentrates | 1 | 15 | 6 | 3 | ([2]) |
| Refined | 605 | 670 | 630 | 734 | 600 |
| General imports, refined | 583 | 649 | 628 | 730 | 590 |
| Exports: | | | | | |
| Ores and concentrates | 137 | 252 | 301 | 348 | 390 |
| Refined | 78 | 40 | 159 | 113 | 100 |
| Consumption: | | | | | |
| Reported, refined | 1,760 | 1,760 | 1,760 | 1,820 | 1,830 |
| Apparent, unmanufactured[3] | 1,760 | 1,730 | 1,770 | 1,770 | 1,810 |
| Price, average, cents per pound: | | | | | |
| Domestic producer, cathode | 348.3 | 405.9 | 367.3 | 339.9 | 322 |
| London Metal Exchange, high-grade | 341.7 | 399.8 | 360.6 | 332.3 | 315 |
| Stocks, yearend, refined, held by U.S. producers, consumers, and metal exchanges | 384 | 409 | 236 | 258 | 190 |
| Employment, mine and mill, thousands | 9.5 | 10.6 | 11.5 | 12.1 | 11.9 |
| Net import reliance[4] as a percentage of apparent consumption | 32 | 34 | 36 | 34 | 31 |

**Recycling:** Old scrap, converted to refined metal and alloys, provided 180,000 tons of copper, equivalent to 10% of apparent consumption. Purchased new scrap, derived from fabricating operations, yielded 640,000 tons of contained copper. Of the total copper recovered from scrap (including aluminum- and nickel-based scrap), brass mills recovered 75%; miscellaneous manufacturers, foundries, and chemical plants, 10%; ingot makers,10%; and copper smelters and refiners, 5%. Copper in all scrap contributed about 32% of the U.S. copper supply.

**Import Sources (2010–13):** Unmanufactured: Chile, 51%; Canada, 26%; Mexico, 13%; Peru, 6%; and other, 4%. Refined copper accounted for 87% of unmanufactured copper imports.

| **Tariff:** Item | Number | Normal Trade Relations[5] 12–31–14 |
|---|---|---|
| Copper ores and concentrates | 2603.00.0000 | 1.7¢/kg on lead content. |
| Unrefined copper anode | 7402.00.0000 | Free. |
| Refined and alloys; unwrought | 7403.00.0000 | 1.0% ad val. |
| Copper wire (rod) | 7408.11.6000 | 3.0% ad val. |

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

**Government Stockpile:** None.

**Events, Trends, and Issues:** The COMEX spot copper price began 2014 at $3.36 per pound of copper. Although fluctuating through several cycles, copper prices on average trended downward during the year in large part owing to reduced demand growth from slower economic growth in China and expectations that the U.S. Federal Reserve would continue cutting its bond purchases during 2014. At the end of August, domestic stocks of refined copper were

Prepared by **Mark Brininstool [(703) 648–7798, mbrininstool@usgs.gov]**

# COPPER

22% lower than those at yearend 2013. The International Copper Study Group (ICSG)[6] projected that in 2014, global refined copper consumption would exceed production by about 310,000 tons. Global production of refined copper was projected to increase by 2.6% and consumption was projected to increase by 5.2%.

U.S. mine production increased by about 14% in 2014, mainly owing to significant increases in production in Arizona, New Mexico, and Utah. Copper production at the Bingham Canyon Mine in Utah increased following recovery from a pit-wall failure in 2013, and in May, a 100,000-metric-ton-per-year expansion of copper in concentrate was completed at the Morenci Mine in Arizona. Total U.S. refined production increased by about 8% owing to across-the-board production increases at electrolytic refineries. In 2015, domestic mine and refined production of copper were expected to increase moderately, and according to ICSG projections, global refined-copper output was expected to exceed demand owing to lower demand growth in China and a 4.3% growth in global refined production.

**World Mine Production and Reserves:** Reserves for the United States were revised owing to general reserves depletion and revised estimates for companies that did not report reserves. Reserves for Australia, Canada, Chile, Peru, and Poland were revised based on new information from the Governments of those countries. Reserves for Indonesia and Kazakhstan were revised based on reported company data.

| | Mine production | | Reserves[7] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 1,250 | 1,370 | 35,000 |
| Australia | 990 | 1,000 | [8]93,000 |
| Canada | 632 | 680 | 11,000 |
| Chile | 5,780 | 5,800 | 209,000 |
| China | 1,600 | 1,620 | 30,000 |
| Congo (Kinshasa) | 970 | 1,100 | 20,000 |
| Indonesia | 504 | 400 | 25,000 |
| Kazakhstan | 446 | 430 | 6,000 |
| Mexico | 480 | 520 | 38,000 |
| Peru | 1,380 | 1,400 | 68,000 |
| Poland | 429 | 425 | 28,000 |
| Russia | 833 | 850 | 30,000 |
| Zambia | 760 | 730 | 20,000 |
| Other countries | 2,200 | 2,400 | 90,000 |
| World total (rounded) | 18,300 | 18,700 | 700,000 |

**World Resources:** A 1998 USGS assessment estimated 550 million tons of copper contained in identified and undiscovered resources in the United States.[9] A 2014 USGS global assessment of copper deposits indicated that known resources contain about 2.1 billion tons of copper (porphyry deposits accounted for 1.8 billion tons of those resources), and undiscovered resources contain an estimated 3.5 billion tons.[10] (For a listing of USGS regional copper resource assessments, go to http://minerals.usgs.gov/global.)

**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]Some electrical components are included in each end use. Distribution for 2013 by the Copper Development Association, Inc., 2014.
[2]Less than ½ unit.
[3]Defined as primary refined production + copper from old scrap converted to refined metal and alloys + refined imports – refined exports ± changes in refined stocks. General imports were used to calculate apparent consumption.
[4]Defined as imports – exports + adjustments for Government and industry stock changes for refined copper.
[5]No tariff for Canada, Chile, Mexico, and Peru for items shown. Tariffs for other countries may be eliminated under special trade agreements.
[6]International Copper Study Group, 2014, Forecast 2014–2015: Lisbon, Portugal, International Copper Study Group press release, October 14, 1 p.
[7]See Appendix C for resource/reserve definitions and information concerning data sources.
[8] For Australia, Joint Ore Reserves Committee (JORC)-compliant reserves were about 25 million 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.
[10]Johnson, K.M., and others, 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)

(Data in million carats unless otherwise noted)

**Domestic Production and Use:** In 2014, total domestic production of industrial diamond was estimated to be 108 million carats with a value of $73.2 million. The United States was one of the world's leading markets. Domestic output was synthetic grit, powder, and stone. Two firms, one in Pennsylvania and another in Ohio, accounted for all of the production. 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 was estimated to be 38.4 million carats. The following industry sectors were the major consumers of industrial diamond: computer chip production, construction, machinery manufacturing, mining services (drilling for mineral, natural gas, and oil exploration), stone cutting and polishing, and transportation systems (infrastructure and vehicles). Stone cutting and highway building, milling, and repair consumed most of the industrial diamond stone. About 97% of the U.S. industrial diamond market now uses synthetic industrial diamond because its quality can be controlled and its properties can be customized to fit specific requirements.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Bort, grit, and dust and powder; natural and synthetic: | | | | | |
| Production: | | | | | |
| Manufactured diamond[e] | 39.3 | 41.5 | 43.7 | 45.7 | 47.9 |
| Secondary | 33.4 | 34.7 | 36.5 | 38.1 | 44.1 |
| Imports for consumption | 596 | 726 | 595 | 728 | 716 |
| Exports | 113 | 148 | 155 | 134 | 152 |
| Consumption, apparent | 556 | 654 | 520 | 678 | 656 |
| Price, value of imports, dollars per carat | 0.14 | 0.13 | 0.13 | 0.11 | 0.11 |
| Net import reliance[1] as a percentage of apparent consumption | 87 | 88 | 85 | 88 | 86 |
| Stones, natural and synthetic: | | | | | |
| Production: | | | | | |
| Manufactured diamond[e] | 53.7 | 56.7 | 59.7 | 62.5 | 65.5 |
| Secondary | 0.46 | 0.31 | 0.33 | 0.34 | 0.39 |
| Imports for consumption[2] | 1.72 | 2.46 | 2.33 | 1.94 | 2.53 |
| Exports | — | — | — | — | — |
| Sales from Government stockpile excesses | — | — | — | — | — |
| Consumption, apparent | 55.9 | 59.4 | 62.3 | 64.8 | 68.4 |
| Price, value of imports, dollars per carat | 18.78 | 19.67 | 15.30 | 15.50 | 12.30 |
| Net import reliance[1] as a percentage of apparent consumption | 3 | 4 | 4 | 3 | 4 |

**Recycling:** In 2014, the amount of diamond bort, grit, and dust and powder recycled was estimated to be 44.1 million carats. Lower prices of newly produced industrial diamond appear to be reducing the number and scale of diamond stone recycling operations. In 2014, it was estimated that 390,000 carats of diamond stone was recycled.

**Import Sources (2010–13):** Bort, grit, and dust and powder; natural and synthetic: China, 79%; Ireland, 9%; Republic of Korea, 4%; Romania, 3%; and other, 5%. Stones, primarily natural: Botswana, 26%; South Africa, 25%; India, 24%; Namibia, 7%; and other, 18%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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. |
| Industrial diamonds, other | 7102.29.0000 | Free. |
| Grit or dust and powder of natural or synthetic diamonds | 7105.10.0000 | Free. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **Donald W. Olson [(703) 648–7721, dolson@usgs.gov]**

# DIAMOND (INDUSTRIAL)

**Events, Trends, and Issues:** In 2014, 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 likely will remain a significant producer and exporter of synthetic industrial diamond as well. U.S. demand for industrial diamond is likely to continue 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. Constant-dollar prices of synthetic diamond products probably will continue to decline as production technology becomes more cost effective; the decline is even more likely if competition from low-cost producers in China and Russia continues to increase.

**World Mine Production and Reserves:**[3] Reserves for Australia were revised based on new Government information.

| | Mine production | | Reserves[4] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | — | NA |
| Australia | 11 | 10 | 250 |
| Botswana | 7 | 7 | 130 |
| Congo (Kinshasa) | 13 | 18 | 150 |
| Russia | 17 | 15 | 40 |
| South Africa | 2 | 5 | 70 |
| Other countries | 10 | 10 | 90 |
| World total (rounded) | 60 | 65 | 730 |

**World Resources:** Natural diamond resources 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]Defined as imports – exports + adjustments for Government and industry stock changes.
[2]May include synthetic miners' diamond.
[3]Natural industrial diamond only. Note that synthetic diamond production far exceeds natural industrial diamond output. Worldwide production of manufactured industrial diamond totaled at least 4.4 billion carats in 2014; the leading producers included Belarus, China, Ireland, Japan, Russia, South Africa, Sweden, and the United States.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.

# DIATOMITE

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** In 2014, production of diatomite was estimated at 800,000 tons with an estimated processed value of $240 million, f.o.b. plant. Six companies produced diatomite at 11 mining areas and 9 processing facilities in California, Nevada, Oregon, and Washington. Diatomite is used in filter aids, 58%; absorbents, 14%; cement, 14%; fillers, 13%; and 1% for other applications, including specialized pharmaceutical and biomedical uses. The unit value of diatomite varied widely in 2014, from approximately $10 per ton for use as a lightweight aggregate in portland cement to more than $400 per ton for limited specialty markets, including art supplies, cosmetics, and DNA extraction.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production[1] | 595 | 813 | 735 | 782 | 800 |
| Imports for consumption | 1 | 2 | 3 | 1 | 3 |
| Exports | 86 | 106 | 96 | 92 | 87 |
| Consumption, apparent | 510 | 709 | 642 | 691 | 716 |
| Price, average value, dollars per ton, f.o.b. plant | 299 | 269 | 286 | 293 | 300 |
| Stocks, producer, yearend[e] | 40 | 40 | 40 | 40 | 40 |
| Employment, mine and plant, number[e] | 660 | 660 | 660 | 660 | 660 |
| Net import reliance[2] as a percentage of apparent consumption | E | E | E | E | E |

**Recycling:** None.

**Import Sources (20010–13):** Mexico, 36%; France, 33%; China, 10%; and others, 21%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Siliceous fossil meals, including diatomite | 2512.00.0000 | Free. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **Robert D. Crangle, Jr. [(703) 648–6410, rcrangle@usgs.gov]**

# DIATOMITE

**Events, Trends, and Issues:** The amount of domestically produced diatomite sold or used by producers in 2014 increased by 3% compared with that of 2013. Apparent domestic consumption increased by 4% in 2014; exports decreased by 5%. Filtration (including the purification of beer, liquors, and wine and the cleansing of greases and oils) continued to be the largest end use for diatomite, also known as diatomaceous earth. Domestically, production of diatomite used as an absorbent 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.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[3] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States[1] | 782 | 800 | 250,000 |
| Argentina | 55 | 55 | NA |
| China | 420 | 430 | 110,000 |
| Denmark[4] (processed) | 335 | 325 | NA |
| France | 75 | 75 | NA |
| Japan | 90 | 100 | NA |
| Mexico | 86 | 86 | NA |
| Peru | 81 | 130 | NA |
| Russia | 70 | 70 | NA |
| Spain | 50 | 50 | NA |
| Turkey | 100 | 100 | NA |
| Other countries | 131 | 138 | NA |
| World total (rounded) | 2,270 | 2,360 | 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. Synthetic filters, 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 imports – exports + adjustments for Government and industry stock changes.
[3]See Appendix C for resource/reserve definitions and information concerning data sources.
[4]Includes sales of moler production.

# FELDSPAR

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** U.S. feldspar production in 2014 had an estimated value of $40 million. The three leading producers accounted for about 79% of production, with four other companies supplying the remainder. Producing States were North Carolina, Idaho, California, Virginia, Oklahoma, Georgia, and South Dakota, in descending order of estimated tonnage. Feldspar processors reported coproduct recovery of mica and silica sand.

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 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 functions as a flux. The estimated 2014 end-use distribution of domestic feldspar was glass, 60%, and ceramic tile, pottery, and other uses, 40%.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, marketable[e] | 500 | 580 | 560 | 550 | 560 |
| Imports for consumption | 2 | 2 | 2 | 4 | 8 |
| Exports | 17 | 17 | 13 | 18 | 16 |
| Consumption, apparent[e] | 485 | 565 | 549 | 536 | 552 |
| Price, average value, marketable production, dollars per ton | 75 | 78 | 66 | 73 | 71 |
| Employment, mine, preparation plant, and office, number[e] | 340 | 400 | 380 | 380 | 380 |
| Net import reliance[1] as a percentage of apparent consumption | E | E | E | E | E |

**Recycling:** Feldspar is not recycled by producers; however, glass container producers use cullet (recycled glass), thereby reducing feldspar consumption.

**Import Sources (2010–13):** Mexico, 50%; Turkey, 33%; Germany, 12%; and other, 5%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Feldspar | 2529.10.0000 | Free. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

**Events, Trends, and Issues:** Glass, including beverage containers and fiberglass insulation for housing and building construction, continued to be the leading end use of feldspar in the United States. Most feldspar consumed by the glass industry is for the manufacture of container glass. The glass container industry was moderately stable, although the trend in recent years to import less-expensive containers from China continued to present challenges to the industry. Additionally, the use of cullet, especially from ongoing growth in post-consumer “bottle-to-bottle” recycling programs, continued to compete as a substitute for primary raw materials such as feldspar, and tended to decrease the demand for them in the manufacture of glass containers.

In 2014, domestic production and sales of feldspar increased slightly from those of 2013. In Europe, consumption declined, mostly owing to continued sluggishness in the region’s construction industry; moderate to strong growth in consumption continued in Asia. Domestically, residential construction, in which feldspar is a raw material used in the production of glass and ceramic tiles, increased in 2014. Consumption of flat glass for residential construction and window replacement in existing housing continued to increase. Housing starts and completions rose by about 7% and 15%, respectively, compared with those of the same period in 2013, and increases were expected to continue in 2015.

Spending on residential construction increased by 6% during the first 9 months of 2014 compared with the same period in 2013. Spending on nonresidential construction, which accounted for about 55% of construction expenditures, also increased by 6% in the first 9 months of 2014 compared with the same period in 2013. Increased residential and nonresidential construction could lead to an increase in feldspar consumption in this sector.

Prepared by **Arnold O. Tanner [(703) 648–4791, atanner@usgs.gov]**

# FELDSPAR

Imports of nepheline syenite, which may be substituted for feldspar in some glass and ceramics manufacture applications, increased slightly in 2014, virtually all coming from Canada.

Fiberglass consumption for thermal insulation was expected to continue to increase in line with housing and commercial building construction in the United States through 2015. Increases in spending on private and public nonresidential construction that took place in 2014 were expected to continue in 2015. Domestic feldspar consumption has been gradually shifting from ceramics toward glass markets. A growing segment in the glass industry was solar glass, used in the production of solar cells.

**World Mine Production and Reserves:** Reserves for India and Venezuela were revised based on new Government information.

| | Mine production | | Reserves[2] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States[e] | 550 | 560 | NA |
| Argentina | 230 | 215 | NA |
| Brazil | 335 | 330 | 320,000 |
| China | 2,100 | 2,100 | NA |
| Czech Republic | 450 | 440 | 25,000 |
| Egypt | 400 | 400 | 5,000 |
| France | 650 | 650 | NA |
| Germany | 205 | 200 | NA |
| India | 1,200 | 1,300 | 45,000 |
| Iran | 580 | 600 | NA |
| Italy | 4,700 | 4,700 | NA |
| Japan | 105 | 100 | NA |
| Korea, Republic of | 350 | 350 | NA |
| Malaysia | 450 | 350 | NA |
| Mexico | 380 | 380 | NA |
| Poland | 380 | 400 | 14,000 |
| Portugal | 113 | 110 | 11,000 |
| Russia | 240 | 240 | NA |
| Saudi Arabia | 168 | 168 | NA |
| South Africa | 191 | 200 | NA |
| Spain | 530 | 530 | NA |
| Thailand | 1,100 | 1,100 | NA |
| Turkey | 5,000 | 5,000 | 240,000 |
| Venezuela | 170 | 500 | 110,000 |
| Other countries | 580 | 600 | NA |
| World total (rounded) | 21,200 | 21,500 | Large |

**World Resources:** Identified and hypothetical 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. Feldspar also 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]Defined as imports – exports.
[2]See Appendix C for resource/reserve definitions and information concerning data sources.

# FLUORSPAR

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** In 2014, minimal fluorspar (calcium fluoride) 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. This company also continued development work and stockpiling of ore for future processing at the Klonkide II fluorspar mine in Kentucky. Synthetic fluorspar was recovered as a byproduct of petroleum alkylation, stainless steel pickling, and uranium processing. However, no data were collected from any of these operations.

U.S. consumption was supplied by imports and small amounts 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 iron and steel casting, primary aluminum production, glass manufacture, enamels, welding rod coatings, cement production, as a flux in steelmaking and in other applications.

An estimated 74,000 tons of fluorosilicic acid (equivalent to about 131,000 tons of 92% fluorspar) was recovered from five phosphoric acid plants processing phosphate rock. Fluorosilicic acid was used primarily in water fluoridation.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production: | | | | | |
| Finished, all grades | NA | NA | NA | NA | NA |
| Fluorspar equivalent from phosphate rock | 128 | 124 | 130 | 131 | 131 |
| Imports for consumption: | | | | | |
| Acid grade | 442 | 560 | 464 | 512 | 350 |
| Metallurgical grade | 97 | 167 | 156 | 130 | 130 |
| Total fluorspar imports | 539 | 727 | 620 | 643 | 480 |
| Hydrofluoric Acid | 135 | 132 | 133 | 119 | 130 |
| Cryolite | 5 | 10 | 8 | 19 | 14 |
| Exports | 18 | 24 | 24 | 16 | 15 |
| Consumption: | | | | | |
| Apparent[1] | 492 | 672 | 525 | 548 | 578 |
| Reported | 503 | 456 | 416 | 441 | 440 |
| Price[2], acid grade, yearend, dollars per ton: | | | | | |
| Filtercake | 260–290 | 400–450 | 400–450 | 350 | 310–350 |
| Arsenic <5 parts per million | 280–320 | 540–550 | 540–550 | 540–550 | 400–450 |
| Stocks, yearend, consumer and dealer[3] | 131 | 162 | 234 | 313 | 200 |
| Employment, mine, number[e] | 4 | 11 | 5 | 6 | 6 |
| Net import reliance[4] as a percentage of apparent consumption | 100 | 100 | 100 | 100 | 100 |

**Recycling:** A few thousand tons per year of synthetic fluorspar are recovered—primarily from uranium enrichment, but also from petroleum alkylation and stainless steel pickling. Primary aluminum producers recycle HF and fluorides from smelting operations. HF is recycled in the petroleum alkylation process.

**Import Sources (2010–13):** Mexico, 75%; China, 15%; South Africa, 7%; Mongolia, 3%.

| **Tariff:** Item | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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 |
| Synthetic Cryolite | 2826.30.0000 | Free |

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

**Government Stockpile:** The last of the Government stocks of fluorspar officially were sold in fiscal year 2007.

Prepared by **Michele E. McRae [(703) 648–7743, mmcrae@usgs.gov]**

# FLUORSPAR

**Events, Trends, and Issues:** Fluorspar prices, particularly those for acid grade fluorspar, continued to decline in 2014. Prices of metallurgical grade fluorspar remained stable. Price declines were largely the consequence of continued global surplus in fluorspar stocks and downstream fluorochemicals. Several leading chemical companies also reported that the weak market had adverse effects on earnings. However, industry analysts reported that the fluorochemicals market will probably rebound in the coming years as new applications for fluoropolymers are developed and the demand for refrigerants in developing countries increases.

Exploration and development work continued at fluorspar projects in Canada, Mongolia, South Africa, the United States, and Vietnam. The status of the projects varied from exploration drilling to mine startups.

**World Mine Production and Reserves:** Production estimates for individual countries were made using country or company-specific data where available; other estimates were made based on general knowledge of end-use markets. The reserves information for Kenya has been revised based on company sources. Spain's reserves were revised to match previously reported estimates.

| | Mine production | | Reserves[5, 6] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | NA | NA | 4,000 |
| Bulgaria | 60 | 50 | NA |
| China | 4,400 | 4,400 | 24,000 |
| Germany | 55 | 50 | NA |
| Iran | 70 | 70 | NA |
| Kazakhstan | 65 | 65 | NA |
| Kenya | 49 | 90 | 5,000 |
| Mexico | 1,230 | 1,200 | 32,000 |
| Mongolia | 226 | 340 | 22,000 |
| Morocco | 76 | 70 | NA |
| Namibia | 50 | 40 | NA |
| Russia | 80 | 20 | NA |
| South Africa | 175 | 230 | 41,000 |
| Spain | 117 | 107 | 6,000 |
| United Kingdom | 45 | 45 | NA |
| Other countries | 73 | 70 | 110,000 |
| World total (rounded) | 6,770 | 6,850 | 240,000 |

**World Resources:** Identified world fluorspar resources were approximately 500 million tons of contained fluorspar. Additionally, there are enormous quantities of fluorine present in phosphate rock. Current U.S. reserves of phosphate rock are estimated to be 1.1 billion tons, which at 3.5% fluorine would contain about 79 million tons of fluorspar equivalent. World reserves of phosphate rock are estimated to be 67 billion tons, equivalent to about 4.8 billion tons of 100% fluorspar equivalent.

**Substitutes:** Aluminum smelting dross, borax, calcium chloride, iron oxides, manganese ore, silica sand, and titanium dioxide have been used as substitutes for fluorspar fluxes. Byproduct fluorosilicic acid has been used as a substitute in aluminum fluoride production and also has the potential to be used as a substitute in HF production.

[e]Estimated. NA Not available.
[1]Excludes fluorspar production withheld for proprietary reasons and fluorspar equivalent of fluorosilicic acid, hydrofluoric acid, and cryolite.
[2]Free on board (f.o.b.), Tampico, Mexico. Source: Industrial Minerals.
[3]Industry stocks for two leading consumers and fluorspar distributors.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix C for resource/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 (crude, 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 gallium from imported primary gallium metal and new scrap. Imports of gallium, which supplied most of U.S. gallium consumption, were valued at about $21 million. Gallium arsenide (GaAs) and gallium nitride (GaN) wafers used in integrated circuits (ICs) and optoelectronic devices accounted for approximately 80% of domestic gallium consumption. Trimethyl gallium and triethyl gallium, metalorganic sources of gallium used in the epitaxial layering process for the production of light-emitting diodes (LEDs), accounted for most of the remainder. About 74% of the gallium consumed was used in ICs. Optoelectronic devices, which include laser diodes, LEDs, photodetectors, and solar cells, accounted for nearly all of the remaining gallium consumption. 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:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production, primary | — | — | — | — | — |
| Imports for consumption | 59,200 | 85,700 | 58,200 | 35,400 | 57,000 |
| Exports | NA | NA | NA | NA | NA |
| Consumption, reported | 33,500 | 35,300 | 34,400 | 37,800 | 40,000 |
| Price, yearend, dollars per kilogram[1] | 600 | 688 | 529 | 502 | 362 |
| Stocks, consumer, yearend | 4,970 | 6,850 | 6,220 | 5,470 | 4,800 |
| Net import reliance[2] as a percentage of reported consumption | 99 | 99 | 99 | 99 | 99 |

**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 (2010–13):** Germany, 36%; United Kingdom, 24%; China, 23%; Ukraine, 6%; and other, 11%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Gallium arsenide wafers, undoped | 2853.00.0010 | 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 and GaAs wafers continued to supply almost all U.S. demand for gallium. Gallium prices decreased throughout 2014, continuing the more than 2-year decline, as significant increases in China's low-grade (99.99%-pure) gallium production continued to exceed increases in worldwide consumption. In January, the price for low-grade gallium in Asia averaged $270 per kilogram. By September, the price had decreased to $240 per kilogram. China's low-grade gallium production capacity has expanded tremendously in recent years, from 140 metric tons per year in 2010 to approximately 550 metric tons per year in 2014 on the expectations of increases in LED-based backlighting and general lighting demand. China accounted for 80% of worldwide low-grade gallium capacity.

Global demand for GaAs- and GaN-based products increased in 2014. GaAs device demand increased by about 6% to $6.25 billion owing to a growing wireless infrastructure in Asia, and growth of feature-rich, application-intensive, third- and fourth-generation "smartphones," which employ up to 10 times the amount of GaAs as standard cellular handsets. Worldwide sales of smartphones exceeded those of standard cellular telephones for the first time in 2013. In 2014, smartphones were estimated to account for 65% of all worldwide cellular telephone sales.

Owing to the large power-handling capabilities, high-switching frequencies, and higher voltage capabilities of GaN technology, GaN-based products, which historically have been used in defense and military applications, have begun to gain acceptance in cable television transmission, commercial wireless infrastructure, power electronics, and satellite markets. The GaN power-device market was forecast to increase at an average annual rate of nearly 29%, to reach $178 million in 2015.

Prepared by **Brian W. Jaskula [(703) 648–4908, bjaskula@usgs.gov]**

# GALLIUM

During the last several years, significant expansion of worldwide LED manufacturing capacity took place, much of it owing to government-instituted incentives to increase LED production, and LED production costs and prices declined. With the rate of adoption of LEDs in television backlighting slowing, however, the LED industry was expected to focus on general lighting applications for the rest of the decade. The highest growth rate in the lighting industry was forecast to be in LED-based tubes to replace fluorescent tubes used in commercial applications, as well as LED-based street lights and LED luminaires of varying sizes. Global shipments of GaN LEDs increased about 7% in 2014, to reach about $13 billion.

In 2014, scientists in Germany achieved a record 21.7% efficiency for a copper-indium-gallium diselenide (CIGS) thin-film solar cell. However, owing to a complicated manufacturing process that has kept the cost of production high, and declining prices for silicon-based solar cells, consumption of CIGS cells have declined. A large oversupply of CIGS modules caused prices to decline by 20% in 2011 and to remain at the lower level into 2014.

**World Production and Reserves:**[3] In 2014, world primary gallium production was estimated to be 440 metric tons—26% more than the revised 2013 world primary production of 350 metric tons. By yearend, some primary gallium producers may have reduced output owing to a large surplus of primary gallium. China, Germany, Japan, and Ukraine were the leading producers; countries with lesser output were Hungary, the Republic of Korea, and Russia. Kazakhstan, which had been a leading producer in 2012, did not produce any primary gallium in 2013, and it was uncertain if it had production in 2014. Refined gallium production in 2014 was estimated to be about 170 metric tons. China, Japan, the United Kingdom, the United States, and possibly Slovakia were the principal producers of refined gallium. Gallium was recycled from new scrap in Canada, Germany, Japan, the United Kingdom, and the United States. World primary gallium production capacity in 2014 was estimated to be 680 metric tons; refinery capacity, 230 metric tons; and secondary capacity, 200 metric tons.

Gallium occurs in very small concentrations in ores of other metals. Most gallium is produced as a byproduct of treating bauxite, and the remainder is produced from zinc-processing residues. Only part of the gallium present in bauxite and zinc ores is recoverable, and the factors controlling the recovery are proprietary. Therefore, an estimate of current reserves comparable to the definition of reserves of other minerals cannot be made.

**World Resources:** The average gallium content of bauxite is 50 parts per million (ppm). 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 as much as 50 ppm gallium and could be a significant resource, although no gallium is currently recovered from domestic ore. Gallium contained in world resources of bauxite is estimated to exceed 1 million metric tons, and a considerable quantity could be contained in world zinc resources. However, only a small percentage 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. Researchers also are working to develop organic-based LEDs that may compete with GaAs in the future. Silicon-based complementary metal-oxide semiconductor (CMOS) power amplifiers compete with GaAs power amplifiers in mid-tier 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 challenged 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]Defined as imports – exports + adjustments for Government and industry stock changes.

[3]See Appendix C for resource/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 2014 by three firms—one in Idaho and two in New York. The estimated value of crude garnet production was about $5.48 million, and refined material sold or used had an estimated value of $8.83 million. Major end uses for garnet were waterjet cutting, 35%; abrasive blasting media, 30%; water filtration, 20%; abrasive powders, 10%; and other end uses, 5%.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production (crude) | 52,600 | 56,400 | 46,900 | 33,900 | 32,200 |
| Production (refined, sold or used) | 28,900 | 33,700 | 25,800 | 32,600 | 30,900 |
| Imports for consumption[e] | 79,700 | 116,000 | 166,000 | 148,000 | 177,000 |
| Exports[e] | 11,700 | 14,500 | 14,600 | 14,400 | 15,700 |
| Consumption, apparent[e, 2] | 121,000 | 158,000 | 199,000 | 167,000 | 193,000 |
| Employment, mine and mill, number[e] | 160 | 160 | 160 | 160 | 150 |
| Net import reliance[3] as a percentage of apparent consumption | 56 | 64 | 76 | 80 | 83 |

**Recycling:** Small amounts of garnet reportedly are recycled.

**Import Sources (2010–13):[e]** Australia, 45%; India, 43%; China, 10%; and other, 2%.

| **Tariff:** Item | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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. |
| Natural abrasives on woven textile | 6805.10.0000 | Free. |
| Natural abrasives on paper or paperboard | 6805.20.0000 | Free. |
| Natural abrasives sheets, strips, disks, belts, sleeves, or similar form | 6805.30.1000 | Free. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **Donald W. Olson [(703) 648–7721, dolson@usgs.gov]**

# GARNET (INDUSTRIAL)

**Events, Trends, and Issues:** During 2014, domestic U.S. production of crude garnet concentrates decreased 5% compared with production of 2013. U.S. garnet production was 2% of total global garnet production. U.S. garnet consumption increased 16% compared with that of 2013. The United States consumed about 12% of global garnet production. In 2014, imports were estimated to have increased by 20% compared with those of 2013, and exports were estimated to have increased by 9% from those of 2013. The 2014 estimated domestic sales or use of refined garnet decreased by 5% compared with sales in 2013. In 2014, the United States remained a net importer. Garnet imports have supplemented U.S. production in the domestic market; Australia, Canada, China, and India were major garnet suppliers.

Garnet prices during 2014 varied over a wide range per metric ton, depending on the amount of processing and refining, degree of fracturing, garnet mineral type, quality, and quantity purchased. Most crude garnet concentrate is priced $75 to $210 per ton, and most refined material is $200 to $335 per ton.

The garnet market is very competitive. To increase profitability and remain competitive with foreign 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, mica minerals, sillimanite, staurolite, wollastonite, or metallic ores.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[4] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 33,900 | 32,200 | 5,000,000 |
| Australia | 263,000 | 260,000 | Moderate to Large |
| China | 510,000 | 520,000 | Moderate to Large |
| India | 800,000 | 800,000 | 6,700,000 |
| Other countries | 50,000 | 50,000 | 6,500,000 |
| World total (rounded) | 1,660,000 | 1,660,000 | 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, and India, 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, Czech Republic, Pakistan, South Africa, 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, 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. Diamond, corundum, and fused aluminum oxide compete for lens grinding and for many lapping operations. Emery is a substitute in nonskid surfaces. Quartz sand, silicon carbide, and fused aluminum oxide compete for the finishing of plastics, wood furniture, and other products.

[e]Estimated.
[1]Excludes gem and synthetic garnet.
[2]Defined as crude production – exports + imports.
[3]Defined as imports – exports.
[4]See Appendix C for resource/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 2014 increased slightly compared with that of 2013. Domestic gemstone production included agate, beryl, coral, garnet, jade, jasper, opal, pearl, quartz, sapphire, shell, topaz, tourmaline, turquoise, and many other gem materials. In decreasing order of production value, Arizona, California, Oregon, Utah, Montana, Tennessee, Colorado, Arkansas, North Carolina, and Idaho produced 86% of U.S. natural gemstones. Laboratory-created gemstones were manufactured by five firms in North Carolina, Florida, 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, owing to the exports values, including reexports values.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production:[2] | | | | | |
| Natural[3] | 10.0 | 11.0 | 11.3 | 9.6 | 9.6 |
| Laboratory-created (synthetic) | 30.8 | 31.9 | 31.2 | 56.9 | 57.0 |
| Imports for consumption | 19,600 | 23,500 | 21,500 | 24,800 | 24,300 |
| Exports, including reexports[4] | 14,100 | 18,200 | 16,900 | 19,400 | 21,900 |
| Consumption, apparent | 5,510 | 5,360 | 4,570 | 5,410 | 2,470 |
| Price | Variable, depending on size, type, and quality | | | | |
| Employment, mine, number[e] | 1,100 | 1,100 | 1,100 | 1,100 | 1,100 |
| Net import reliance[5] as a percentage of apparent consumption | 99 | 99 | 99 | 99 | 97 |

**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 (2010–13 by value):** Israel, 39%; India, 26%; Belgium, 19%; South Africa, 5%; and other, 11%. Diamond imports accounted for 93% of the total value of gem imports.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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, 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. |
| Jadeite, unworked | 7103.10.2020 | Free. |
| Other gemstones, unworked | 7103.10.2040 | Free. |
| Rubies, cut | 7103.91.0010 | Free. |
| Sapphires, cut | 7103.91.0020 | Free. |
| Emeralds, cut | 7103.91.0030 | Free. |
| Jadeite, cut but not set | 7103.99.1020 | Free. |
| Other gemstones, cut but not set | 7103.99.1080 | Free. |
| Jadeite, otherwise worked | 7103.99.5020 | 10.5% ad val. |
| Other gemstones, otherwise worked | 7103.99.5080 | 10.5% ad val. |
| Synthetic gemstones, cut but not set | 7104.90.1000 | Free. |
| Synthetic gemstones, other | 7104.90.5000 | 6.5% ad val. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **Donald W. Olson [(703) 648–7721, dolson@usgs.gov]**

# GEMSTONES

**Events, Trends, and Issues:** In 2014, the U.S. market for gem-quality diamonds was estimated to be about $22.5 billion compared with $23.3 billion in 2013. This accounted for more than 35% of world demand. The domestic market for natural, nondiamond gemstones was estimated to be about $1.78 billion compared with $1.40 billion in 2013. The United States is expected to continue dominating global gemstone consumption.

**World Gem Diamond Mine Production and Reserves:**

| | Mine production[6] | | Reserves[7] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| Angola | 8,420 | 8,400 | World reserves of diamond-bearing deposits are substantial. No reserve data are available for other gemstones. |
| Australia | 235 | 235 | |
| Botswana | 16,231 | 16,000 | |
| Brazil | 49 | 48 | |
| Canada | 10,600 | 11,600 | |
| Congo (Brazzaville) | 56 | 60 | |
| Congo (Kinshasa) | 3,140 | 4,400 | |
| Guinea | 162 | 160 | |
| Guyana | 60 | 60 | |
| Lesotho | 414 | 410 | |
| Namibia | 1,690 | 1,500 | |
| Russia | 21,200 | 23,000 | |
| Sierra Leone | 457 | 300 | |
| South Africa | 6,520 | 6,500 | |
| Tanzania | 153 | 180 | |
| Zimbabwe | 1,040 | 1,000 | |
| Other countries | 215 | 200 | |
| World total (rounded) | 70,600 | 74,100 | |

**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. The major gem diamond reserves are in southern Africa, Australia, Canada, and Russia.

**Substitutes:** Plastics, glass, 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 90% of the totals.
[5]Defined as imports – exports and reexports.
[6]Data in thousands of carats of gem diamond.
[7]See Appendix C for resource/reserve definitions and information concerning data sources.

# GERMANIUM

(Data in kilograms of germanium content unless otherwise noted)

**Domestic Production and Use:** Germanium production in the United States comes from either the processing of imported germanium compounds or recycling domestic industry-generated scrap. Germanium for domestic consumption also was obtained from materials imported in chemical form and either directly consumed or consumed in the production of other germanium compounds. Germanium was recovered from zinc concentrates produced at a mine in Alaska and exported to Canada for processing. A zinc smelter in Clarksville, Tennessee, produced and exported germanium leach concentrates recovered from processing zinc concentrates from its Middle Tennessee Mines. A germanium refinery in Utica, NY, produced germanium tetrachloride for optical fiber production. Another refinery in Quapaw, OK, produced refined germanium and compounds from scrap and imported materials for the production of fiber optics, infrared devices, and substrates for electronic devices. The worldwide end-use pattern of germanium was estimated to be: fiber optics, 30%; infrared optics, 20%; polymerization catalysts, 20%; electronics and solar applications, 15%; and other uses (such as phosphors, metallurgy, and chemotherapy), 15%. The domestic end-use distribution was different and was estimated to be: fiber-optic systems, 40%; infrared optics, 30%; electronics and solar applications, 20%; and other uses, 10%. Germanium was not used in polymerization catalysts in the United States. In 2014, domestic consumption of germanium for fiber-optic systems increased compared with that in 2013 but use in infrared optics declined. The estimated value of germanium metal consumed in 2014, based on the annual average producer price, was about $67 million.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, refinery[e] | 3,000 | 3,000 | W | W | W |
| Total imports[1] | 44,700 | 38,500 | 48,500 | 45,700 | 45,000 |
| Total exports[1] | 8,000 | 5,900 | 15,300 | 12,500 | 11,000 |
| Shipments from Government stockpile excesses | — | — | — | — | — |
| Consumption, estimated | 40,000 | 36,000 | 38,000 | 38,000 | 35,000 |
| Price, producer, yearend, dollars per kilogram: | | | | | |
| Zone refined | 1,200 | 1,450 | 1,640 | 1,900 | 1,900 |
| Dioxide, electronic grade | 720 | 1,250 | 1,360 | 1,230 | 1,300 |
| Stocks, producer, yearend | NA | NA | NA | NA | NA |
| Net import reliance[2] as a percentage of estimated consumption | 90 | 90 | 85 | 85 | 95 |

**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 was also recovered from the window blanks in decommissioned tanks and other military vehicles.

**Import Sources (2010–13):**[3] China, 65%; Belgium, 15%; Russia, 11%; Canada, 4%; and other, 5%.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Germanium oxides | 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:** In fiscal year 2012, the Defense Logistics Agency Strategic Materials awarded two contracts to convert 3,000 kg of the germanium ingots held in the stockpile to epitaxial wafers for use as substrates required by National Security Space Strategy photovoltaic solar cell applications. As of October 2014, the germanium was converted to 101,939 germanium epitaxial wafers and held for the stockpile at private warehouses.

**Stockpile Status—9–30–14**[4]

| Material | Inventory | Disposal Plan FY 2015 | Disposals FY 2015 |
|---|---|---|---|
| Germanium | 13,364 | — | — |

Prepared by **David E. Guberman [(703) 648–4977, dguberman@usgs.gov]**

# GERMANIUM

**Events, Trends, and Issues:** In 2014, a zinc mine in Washington that was placed on temporary care-and-maintenance status in February 2009 was reopened. The operator began ramping up operations and planned to produce the first concentrates by yearend 2014. It was estimated that at full capacity, the mine could produce 5 to 6 metric tons of germanium per year. Concentrates from the mine would be processed at the company's metallurgical plant in Canada.

Germanium dioxide prices were relatively stable during the first three quarters of 2014, remaining close to 2013 levels, and nearly double those in 2010. Germanium metal began the year at about $1,900 per kilogram, increased to $1,950 per kilogram in March, and was about $1,900 per kilogram by late October. At current price levels, some consumers were finding it cheaper to purchase germanium metal instead of dioxide owing to the lower unit cost of the germanium contained in metal. Stockpiling in China may have contributed to global germanium metal price increases.

Germanium consumption is heavily reliant on military use and consumption declined in 2014 owing to cuts in defense-related spending. Outside of China, less germanium was used for infrared optics, substrates for terrestrial-based solar cells, and light-emitting diodes than in 2013. Germanium consumption increased for use in fiber optics.

In 2014, China remained the leading global consumer and producer of germanium. A handful of leading manufacturers in China account for most of global production. Stockpiling activities in China have contributed to global price increases since 2010 by limiting the amount of germanium that is available to consumers. In 2014, China's State Reserve Bureau purchased 30 metric tons of germanium for its national stockpile (20 metric tons was stockpiled in 2013) and analysts expected that China would continue to stockpile germanium during the next several years. The Fanya Metal Exchange in China, established for investing in "rare" metals, had more than 91 metric tons of germanium in warehouses as of late November and had the capacity to hold 200 metric tons. National and Provincial governments in China encouraged producers to integrate operations and focus on producing value-added products. China's trade policies during recent years, such as a 5% export tax placed on germanium dioxide, have been aimed at reducing exports of minor metals and encouraging the export of downstream products. China's exports of germanium metal during the first 10 months of 2014 declined by 52% from those in the same period of 2013.

**World Refinery Production and Reserves:**

| | Refinery production[e] | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014 | |
| United States | W | W | Data on the recoverable content of zinc ores are not available. |
| China | 110,000 | 120,000 | |
| Russia | 5,000 | 5,000 | |
| Other countries | 40,000 | 40,000 | |
| World total | [6]155,000 | [6]165,000 | |

**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 metric 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. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.

[1]In addition to the gross weight of wrought and unwrought germanium and waste and scrap that comprise these figures, this series includes estimated germanium content of germanium dioxide. This series does not include germanium tetrachloride and other germanium compounds for which data are not available.

[2]Defined as imports – exports + adjustments for Government stock changes; rounded to nearest 5%.

[3]Imports are based on the gross weight of wrought and unwrought germanium and waste and scrap, but not germanium tetrachloride and other germanium compounds for which data are not available.

[4]See Appendix B for definitions.

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

[6]Excludes U.S. production.

# GOLD

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

**Domestic Production and Use:** In 2014, domestic gold mine production was estimated to be about 211 tons, 8% less than in 2013, and the value was estimated to be about $8.6 billion. Gold was produced at about 45 lode mines, a few large placer mines (all in Alaska), and numerous smaller placer mines (mostly in Alaska and in the Western States). In addition, 7% of domestic gold was recovered as a byproduct of processing domestic base metals, chiefly copper. Thirty operations yielded more than 99% of the gold produced in the United States. Commercial-grade refined gold came from about two dozen producers. 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 were jewelry; 41% electrical and electronics, 35%; official coins, 18%; dental, 4%; and other, 2%.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine | 231 | 234 | 235 | 230 | 211 |
| Refinery: | | | | | |
| Primary | 175 | 220 | 222 | 223 | 200 |
| Secondary (new and old scrap) | 198 | 263 | 215 | 210 | 200 |
| Imports for consumption[2] | 616 | 550 | 326 | 315 | 315 |
| Exports[2] | 383 | 644 | 695 | 691 | 430 |
| Consumption, reported | 180 | 168 | 147 | 160 | 165 |
| Stocks, yearend, Treasury[3] | 8,140 | 8,140 | 8,140 | 8,140 | 8,140 |
| Price, dollars per troy ounce[4] | 1,228 | 1,572 | 1,673 | 1,415 | 1,270 |
| Employment, mine and mill, number[5] | 10,300 | 11,100 | 12,700 | 12,958 | 12,500 |
| Net import reliance[6] as a percentage of apparent consumption | ([7]) | ([7]) | ([7]) | ([7]) | ([7]) |

**Recycling:** In 2014, 200 tons of new and old scrap was recycled, more than the reported consumption.

**Import Sources (2010–13):**[2] Mexico, 52%; Canada, 17%; Colombia, 11%; Peru, 7%; and other, 13%.

**Tariff:** Most imports of unwrought gold, including bullion and doré, enter the United States duty 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 2014 was 10% lower than the price in 2013 and was down by 24% from the record-high annual price in 2012. The Engelhard daily price of gold in 2014 fluctuated through several cycles. The gold price began the year at $1,226.73 per troy ounce and increased to $1,387 per troy ounce on March 14, the highest level of the year. The price trended downward to $1,247.77 per troy ounce on June 3 and then rebounded to $1,343.53 per troy ounce on July 10. The price then trended downward, ending October at $1,166.83 per troy ounce, the lowest price since July 2010. Many believe that the average gold price decreased owing to the lack of confidence in gold as an investment.

The decrease in domestic mine production was attributed to lower ore grades at the two leading producers in Nevada. These decreases were partly offset by one mine in Utah, which continued to recover following a massive landslide in April 2013.

In 2014, worldwide gold production was 2% more than that in 2013 owing to increases in production from Australia, Canada, China, the Dominican Republic, and Russia, which more than offset production decreases in Peru, Tanzania, South Africa, and the United States. Gold production in China continued to increase, and the country remained the leading gold-producing nation, followed by Australia, Russia, the United States, Peru, and Canada. Following the decline in price, the domestic and global supply of gold from recycling continued to decline from the high level in 2011 to nearer the long-term average.

Prepared by **Micheal W. George [(703) 648–4962, mgeorge@usgs.gov]**

# GOLD

In 2014, domestic consumption of gold used in the production of jewelry and electronics increased because of the lower price of gold and improved economic environment. Consumption of gold used in manufacturing jewelry in Asia and the Middle East, however, was significantly lower; consumption in 2013 had been significantly higher than prior years' levels. Domestic and global investment demand for gold decreased because of the lower price, especially in China and India. Gold stored in the exchange-traded funds has also decreased in the last 2 years, while Central Banks continue to purchased gold bullion.

Gold mining has been identified as a potential source of funding for armed groups engaged in civil unrest in Congo (Kinshasa) (DRC) and surrounding countries. The United States, through the enactment of Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank Act) on July 21, 2010, made it a statutory obligation for all companies registered with the U.S. Securities and Exchange Commission (SEC) to perform due diligence to determine whether the products they manufacture, or the components of the products they manufacture, contain tantalum, tin, tungsten and gold (3TG) minerals and if so, to determine whether these minerals were sourced from the DRC and (or) its bordering countries.

**World Mine Production and Reserves:** Reserves for Australia, Canada, and Peru were revised based on information from the respective country Governments.

| | Mine production | | Reserves[8] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 230 | 211 | 3,000 |
| Australia | 265 | 270 | 9,800 |
| Brazil | 71 | 70 | 2,400 |
| Canada | 124 | 160 | 2,000 |
| Chile | 51 | 50 | 3,900 |
| China | 430 | 450 | 1,900 |
| Ghana | 90 | 90 | 2,000 |
| Indonesia | 61 | 65 | 3,000 |
| Mexico | 98 | 92 | 1,400 |
| Papua New Guinea | 57 | 60 | 1,200 |
| Peru | 151 | 150 | 2,100 |
| Russia | 230 | 245 | 5,000 |
| South Africa | 160 | 150 | 6,000 |
| Uzbekistan | 98 | 102 | 1,700 |
| Other countries | 684 | 695 | 10,000 |
| World total (rounded) | 2,800 | 2,860 | 55,000 |

**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.
[1]One metric ton (1,000 kilograms) = 32,150.7 troy ounces.
[2]Refined bullion, doré, 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: 0 (2010), -4 (2011), 0 (2012), 5 (2013), and 70 (2014, estimate).
[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 2014, the price was estimated by the USGS based on monthly data from January through October.
[5]Data from Mine Safety and Health Administration.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]In recent years, the United States has been a net exporter; however, large unreported investor stock changes preclude calculation of a meaningful net import reliance.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.
[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 2014, approximately 90 U.S. firms, primarily in the Northeastern and Great Lakes regions, consumed 53,200 tons valued at $57.5 million. The major uses of natural graphite in 2014 were brake linings, foundry operations, lubricants, refractory applications, and steelmaking. During 2014, U.S. natural graphite imports were 62,400 tons, which were 65% flake and high-purity graphite and 35% amorphous graphite.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production, mine | — | — | — | — | — |
| Imports for consumption | 65 | 72 | 57 | 61 | 62 |
| Exports | 6 | 6 | 6 | 9 | 9 |
| Consumption, apparent[1] | 60 | 66 | 50 | 52 | 53 |
| Price, imports (average dollars per ton at foreign ports): | | | | | |
| Flake | 720 | 1,180 | 1,370 | 1,330 | 1,540 |
| Lump and chip (Sri Lankan) | 1,700 | 1,820 | 1,960 | 1,720 | 1,890 |
| Amorphous | 257 | 301 | 339 | 375 | 364 |
| 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 recycling of graphite products. The market for recycled refractory graphite material is growing, 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 (2010–13):** China, 45%; Mexico, 28%; Canada, 17%; Brazil, 6%; and other, 4%.

| **Tariff:** Item | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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.

Prepared by **Donald W. Olson [(703) 648–7721, dolson@usgs.gov]**

# GRAPHITE (NATURAL)

**Events, Trends, and Issues:** Worldwide demand for graphite steadily increased throughout 2012, 2013, and into 2014. This increase resulted from the improvement of global economic conditions and its impact on industries that use graphite. Principal import sources of natural graphite were, in descending order of tonnage, Mexico, China, Canada, Brazil, and Madagascar, which combined, accounted for 96% of the tonnage and 89% of the value of total imports. Mexico provided all the amorphous graphite, and Sri Lanka provided all the lump and chippy dust variety. China, Canada, and Madagascar were, in descending order of tonnage, the major suppliers of crystalline flake and flake dust graphite.

During 2014, China produced 67% of the world's graphite and consumed 35%. Graphite production increased in Canada, China, Madagascar, Mexico, Turkey, and Zimbabwe from that of 2013, and production decreased in Brazil from 2013 production levels.

North America only produced 2% of the world's graphite supply with production in Canada and Mexico. No production of natural graphite was reported in the United States, but three companies recently have been exploring for and 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. National Graphite Corp. had been developing the Chedic Graphite Project in Nevada, but abandoned that project.

One U.S. auto maker was building a large plant to manufacture lithium-ion electric vehicle batteries. The plant's projected completion was expected by 2020, and it would require 93,000 tons of flake graphite for use as anode material. 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 special 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 were revised based on information reported by the Government of Brazil.

| | Mine production | | Reserves[2] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | — | — |
| Brazil | 95 | 80 | 40,000 |
| Canada | 20 | 30 | ([3]) |
| China | 750 | 780 | 55,000 |
| India | 170 | 170 | 11,000 |
| Korea, North | 30 | 30 | ([3]) |
| Madagascar | 4 | 5 | 940 |
| Mexico | 7 | 8 | 3,100 |
| Norway | 2 | 2 | ([3]) |
| Russia | 14 | 14 | ([3]) |
| Sri Lanka | 4 | 4 | ([3]) |
| Turkey | 5 | 30 | ([3]) |
| Ukraine | 6 | 6 | ([3]) |
| Zimbabwe | 4 | 6 | ([3]) |
| Other countries | 1 | 1 | ([3]) |
| World total (rounded) | 1,110 | 1,170 | 110,000 |

**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/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 2014, domestic production of crude gypsum was estimated to be 17.1 million tons with a value of about $154 million. The leading crude gypsum-producing States were, in descending order, Texas, Oklahoma, Kansas, Nevada, Indiana, and California, which together accounted for 69% of total output. Overall, 47 companies produced or processed gypsum in the United States at 118 mines and plants in 17 States. Approximately 90% of domestic consumption, which totaled approximately 29 million tons, was accounted for by manufacturers of wallboard and plaster products. Approximately 1.5 million tons of gypsum used in cement production and agricultural applications and small amounts of high-purity gypsum in a wide range of industrial processes accounted for the remaining tonnage. At the beginning of 2014, the production capacity of operating wallboard plants in the United States was about 33 billion square feet[1] per year.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production: | | | | | |
| Crude | 10,200 | 10,500 | 15,800 | 16,300 | 17,100 |
| Synthetic[2] | 10,700 | 11,800 | 12,100 | 12,800 | 13,200 |
| Calcined[3] | 12,400 | 11,900 | 12,800 | 14,600 | 15,300 |
| Wallboard products sold (million square feet[1]) | 17,100 | 17,200 | 18,900 | 21,800 | 22,000 |
| Imports, crude, including anhydrite | 3,330 | 3,330 | 3,250 | 3,290 | 3,500 |
| Exports, crude, not ground or calcined | 360 | 316 | 408 | 142 | 70 |
| Consumption, apparent[4] | 23,900 | 25,300 | 30,700 | 32,200 | 33,700 |
| Price: | | | | | |
| Average crude, f.o.b. mine, dollars per metric ton | 6.90 | 8.20 | 7.70 | 8.83 | 9.00 |
| Average calcined, f.o.b. plant, dollars per metric ton | 29.70 | 28.70 | 28.70 | 27.60 | 28.00 |
| Employment, mine and calcining plant, number[e] | 4,500 | 4,500 | 4,500 | 4,500 | 4,500 |
| Net import reliance[5] as a percentage of apparent consumption | 12 | 12 | 9 | 10 | 10 |

**Recycling:** Some of the more than 4 million tons of gypsum scrap that was generated by wallboard manufacturing, wallboard installation, and building demolition was recycled. The 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 (20010–13):** Canada, 42%; Mexico, 39%; and Spain, 18%; and other, 1%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Gypsum; anhydrite | 2520.10.0000 | Free. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

**Events, Trends, and Issues:** U.S. gypsum production increased by 5% compared with that of 2013 because the housing and construction markets increased in activity and almost reached productions not seen since 2007. Apparent consumption increased by 5% compared with that of 2013. The world's leading gypsum producer, China, produced about eight times the amount produced in the United States. Iran, ranked third in world production, supplied much of the gypsum needed for construction in the Middle East. Spain, the leading European producer, ranked fifth in the world and supplied crude gypsum and gypsum products to much of Western Europe. An 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, 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 about 95% 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 coal flue gas desulfurization (FGD) units as feedstock continues, this could result in less mining of natural gypsum. The availability of inexpensive natural gas, however, may limit the increase of future FGD units and, therefore, the production of synthetic gypsum. Gypsum imports increased by 6% compared with those of 2013. Exports, although very low compared with imports and often subject to wide fluctuations, decreased by 51%.

Prepared by **Robert D. Crangle, Jr. [(703) 648–6410, rcrangle@usgs.gov]**

# GYPSUM

**World Mine Production and Reserves:**

| | Mine production | | Reserves[6] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 16,300 | 17,100 | 700,000 |
| Algeria | 1,700 | 2,100 | NA |
| Argentina | 1,440 | 1,400 | NA |
| Australia | 3,500 | 3,500 | NA |
| Brazil | 3,750 | 3,700 | 230,000 |
| Canada | 2,650 | 1,800 | 450,000 |
| China | 129,000 | 132,000 | NA |
| France | 2,300 | 2,300 | NA |
| Germany | 1,950 | 1,900 | NA |
| India | 3,540 | 3,500 | 69,000 |
| Iran | 15,000 | 13,000 | NA |
| Italy | 4,100 | 4,100 | NA |
| Japan | 5,500 | 5,500 | NA |
| Mexico | 5,090 | 5,000 | NA |
| Oman | 2,790 | 3,000 | NA |
| Poland | 1,270 | 1,300 | 55,000 |
| Russia | 5,100 | 5,300 | NA |
| Saudi Arabia | 2,400 | 2,400 | NA |
| Spain | 6,400 | 6,400 | NA |
| Thailand | 6,300 | 6,300 | NA |
| Turkey | 8,300 | 8,300 | NA |
| United Kingdom | 1,700 | 1,700 | NA |
| Other countries | 14,500 | 14,500 | NA |
| World total (rounded) | 245,000 | 246,000 | 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; 90 countries produced gypsum in 2014.

**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 tonnage order). In 2014, 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 $9.29 \times 10^{-2}$ to convert to square meters. Source: The Gypsum Association.
[2]Data refer to the amount sold or used, not produced.
[3]From domestic crude and synthetic.
[4]Defined as crude production + total synthetic reported used + imports – exports.
[5]Defined as imports – exports.
[6]See Appendix C for resource/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 better) extracted domestically during 2014 by private industry was about $930 million. Ten plants (five in Kansas, four in Texas, and one in Wyoming) extracted helium from natural gas and produced only a crude helium product that varied from 50% to 99% helium. Two plants (one in Colorado and one in Wyoming) extracted helium from natural gas and produced a Grade-A helium product. Six plants (four in Kansas, one in Oklahoma, and one in Texas) accepted a crude helium product from other producers and the Bureau of Land Management (BLM) pipeline and purified it to a Grade-A helium product. Estimated 2014 domestic consumption of helium was 34 million cubic meters (1.2 billion cubic feet) and was used for cryogenic applications, 32%; for pressurizing and purging, 18%; for controlled atmospheres, 18%; for welding cover gas, 13%; leak detection, 4%; breathing mixtures, 2%; and other, 13%.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Helium extracted from natural gas[2] | 75 | 71 | 73 | 69 | 73 |
| Withdrawn from storage[3] | 53 | 59 | 60 | 49 | 30 |
| Grade-A helium sales | 128 | 130 | 133 | 118 | 103 |
| Imports for consumption | — | — | — | — | — |
| Exports[4] | 77 | 82 | 85 | 81 | 69 |
| Consumption, apparent[4] | 51 | 48 | 48 | 37 | 34 |
| Net import reliance[5] as a percentage of apparent consumption | E | E | E | E | E |

Price: In fiscal year (FY) 2014, the price for crude helium to Government users was $2.49 per cubic meter ($69.00 per thousand cubic feet) and to nongovernment users was $3.43 per cubic meter ($95.00 per thousand cubic feet). The price for Government-owned helium is mandated by the Helium Privatization Act of 1996 (Public Law 104–273). The estimated price range for private industry's Grade-A gaseous 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 more common.

**Import Sources (2010–13):** None.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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 Public Law 113–40, the BLM manages the Federal Helium Program, which includes all operations of the Cliffside Field helium storage reservoir, in Potter County, Texas, 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 Helium Stewardship Act of 2013 mandated that the BLM sell Federal Conservation helium stored in Bush Dome at the Cliffside Field annually at sale and auction. The amounts sold are to be approximately equal to the amount the Federal helium system can produce each year. By 2021, or when the remaining conservation helium is less than 83 million cubic meters, the Federal Government is to dispose of all helium related-assets.

In FY 2014, privately owned companies purchased about 42.3 million cubic meters (83 million cubic feet) of in-kind crude helium. In addition to this, privately owned companies also purchased 16.9 million cubic meters (610 million cubic feet) of open market sales helium. During FY 2014, the BLM's Amarillo Field Office, Helium Operations (AMFO), accepted about 10.7 million cubic meters (387 million cubic feet) of private helium for storage and redelivered nearly 43.2 million cubic meters (1,558 million cubic feet). As of September 30, 2014, about 50.6 million cubic meters (1,826 million cubic feet) of privately owned helium remained in storage at Cliffside Field.

**Stockpile Status—9–30–14[6]**

| Material | Inventory | Authorized for disposal | Disposal plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|---|
| Helium | 251.1 | 251.1 | 38.8 | 30.5 |

Prepared by **John E. Hamak[7] [(806) 356–1031, jhamak@blm.gov]**

# HELIUM

**Events, Trends, and Issues:** In 2014, as part of the implementation of the Helium Stewardship Act of 2013, the BLM began an auction process to price helium more closely to the open market value. The average price of helium sold to private buyers as a result of this process was $3.82 per cubic meter ($106 per thousand cubic feet). 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 for the next 3 to 5 years. Expansions to facilities have been completed as planned in Algeria and Qatar. In 2014, demand for helium worldwide increased, but domestic demand continued to decrease. Additionally in 2014, new domestic production began in Wyoming and more production was expected to start in southwest Colorado in 2015. As a result, demand for the Government's helium production has decreased by 50% over the past 2 years.

**World Production and Reserves:**

| | Production | | Reserves[8] |
|---|---|---|---|
| | 2013[e] | 2014[e] | |
| United States (extracted from natural gas) | 69 | 73 | 3,900 |
| United States (from Cliffside Field) | 49 | 30 | ([9]) |
| Algeria | 17 | 25 | 1,800 |
| Australia | 6 | 6 | NA |
| Canada | NA | NA | NA |
| China | NA | NA | NA |
| Poland | 3 | 3 | 25 |
| Qatar | 25 | 40 | NA |
| Russia | 6 | 5 | 1,700 |
| Other countries | NA | NA | NA |
| World total (rounded) | 175 | 180 | NA |

**World Resources:** 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 (153.2 billion cubic feet) of measured reserves, 5.33 billion cubic meters (192.2 billion cubic feet) of probable resources, 5.93 billion cubic meters (213.8 billion cubic feet) of possible resources, and 5.11 billion cubic meters (184.4 billion cubic feet) of speculative resources. Included in the measured reserves are 0.67 billion cubic meters (24.2 billion cubic feet) of helium stored in the Cliffside Field Government Reserve, and 0.065 billion cubic meters (2.3 billion cubic feet) of helium contained in Cliffside Field native gas. The depleting fields from which most U.S.-produced helium is extracted are Hugoton in Kansas, Oklahoma, and Texas; Panhandle West in Texas; Panoma in Kansas; Riley Ridge in Wyoming; and Cliffside in Texas. 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, 2010, the AMFO had analyzed about 22,000 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. — Zero.

[1]Measured at 101.325 kilopascals absolute [14.696 pounds per square inch absolute (psia)] and 15 °C; 27.737 cubic meters of helium = 1 Mcf 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.

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

[9]Included in United States (extracted from natural gas) reserves.

# INDIUM

(Data in metric tons unless otherwise noted)

**Domestic Production and Use:** Indium was not recovered from ores in the United States in 2014. 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 recent annual import levels, estimated domestic consumption ranges between 100 and 150 tons. The estimated value of primary indium metal consumed domestically in 2014, based on the average New York dealer price, was between $69.5 million and $104 million.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, refinery | — | — | — | — | — |
| Imports for consumption | 117 | 146 | 109 | 97 | 120 |
| Exports | NA | NA | NA | NA | NA |
| Price, annual average, dollars per kilogram: | | | | | |
| U.S. producer[1] | 565 | 720 | 650 | 615 | 735 |
| New York dealer[2] | 552 | 685 | 540 | 570 | 695 |
| 99.99% c.i.f. Japan[3] | 546 | 680 | 510 | 575 | 700 |
| Net import reliance[4] as a percentage of estimated consumption | 100 | 100 | 100 | 100 | 100 |

**Recycling:** Data on the quantity of secondary indium recovered from scrap were not available. Indium is most commonly recovered from ITO scrap in Japan and the Republic of Korea.

**Import Sources (2010–13):** China, 21%; Canada, 21%; Belgium, 14%; Japan, 11%; and other, 33%.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Unwrought indium, including powders | 8112.92.3000 | Free. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

**Events, Trends, and Issues:** The estimated annual average New York dealer price of indium was $695 per kilogram, 22% more than that of 2013. The New York dealer price range for indium began the year at $670 to $700 per kilogram and increased through the first half of the year, reaching $710 to $750 per kilogram in mid-July. Prices then trended downward, falling to $645 per kilogram to $685 per kilogram in early October. The U.S. producer price for indium began the year at $680 per kilogram and increased to $745 per kilogram in February, where it remained through October.

According to market reports, global indium consumption increased slightly in 2014 from that of 2013 to about 1,500 tons. Japan and the Republic of Korea were thought to have accounted for most of global consumption for the production of ITO. Increased indium consumption was reportedly driven by increased demand for LCD televisions in developing countries and for smartphones and tablets, which use small LCD panels, in developed countries.

A Japanese company was in the process of constructing its fourth copper-indium-gallium-selenide (CIGS) solar cell production plant in the Tohoku region of Japan. The plant was expected to begin production in 2015. The company was reportedly the only mass producer of CIGS solar cells and consumed about 20 tons per year of indium at its three other CIGS solar cell production plants in Miyazaki (Kyushu region).

Prepared by **Amy C. Tolcin [(703) 648–4940, atolcin@usgs.gov]**

# INDIUM

In China, two large-scale ITO projects were under development and expected to begin production in late 2014 or 2015. Once onstream, they would increase China's indium consumption, which was reported to be about 70 tons in 2013. One of the plants, located in Quingyuan, would have an ITO production capacity of 200 tons per year. The other plant did not release capacity information.

Reported inventories of indium held in China's Fanya Nonferrous Metals Exchange approved warehouses increased by 1,240 tons in the first 9 months of 2014 to 3,240 tons. Some market participants questioned the magnitude of the reported increase, considering that the amount was about triple China's annual indium production in 2013 and that imports of indium in 2014 were relatively low. During the first 8 months of 2014, China imported 27 tons of unwrought indium, 72% less than the amount imported during the corresponding period of 2013.

**World Refinery Production and Reserves:**

| | Refinery production | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | — | Quantitative estimates of reserves are not available. |
| Belgium | 30 | 30 | |
| Canada | 65 | 65 | |
| China | 415 | 420 | |
| France | 33 | 48 | |
| Germany | 10 | 10 | |
| Japan | 72 | 72 | |
| Korea, Republic of | 150 | 150 | |
| Peru | 11 | 11 | |
| Russia | 13 | 13 | |
| World total (rounded) | 799 | 820 | |

**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 metals are subeconomic for indium.

**Substitutes:** Indium's price volatility and various supply concerns associated with the metal have spurred the development of ITO 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; and poly(3,4-ethylene dioxythiophene) (PEDOT) has also been developed as a substitute for ITO in flexible displays and organic light-emitting diodes. Graphene has been developed to replace ITO electrodes in solar cells and also have been explored as a replacement for ITO in flexible touchscreens. 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]Indium Corp.'s price for 99.97%-purity metal, free on board. Source: Platts Metals Week, Metal Bulletin.
[2]Price is based on 99.99%-minimum-purity indium at warehouse (Rotterdam); cost, insurance, and freight (in minimum lots of 50 kilograms). Source: Platts Metals Week.
[3]Price is based on 99.99%-purity indium, primary or secondary, shipped to Japan. Source: Platts Metals Week.
[4]Defined as imports – exports.
[5]See Appendix C for resource/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 2014 by two companies operating in Oklahoma, and one company operating in Kentucky, Montana, Oklahoma, and Texas. Production in 2014 was estimated to have increased from that of 2013. To avoid disclosing company proprietary data, U.S. iodine production in 2014 was withheld. Prices for iodine have continued to decline in 2014 owing to the surplus of iodine in the market. The average cost, insurance, and freight value of iodine imports in 2014 was estimated to be $39.00 per kilogram.

Domestic and imported iodine were used by downstream manufacturers to produce many intermediate iodine compounds, making it difficult to establish an accurate end-use pattern. Of the consumers that participate in an annual U.S. Geological Survey canvass, 12 plants reported consumption of iodine in 2013. Iodine and iodine compounds reported were ethyl and methyl iodide, 49%; potassium iodide, 16%; povidine-iodine, 5%; crude iodine, ethylenediamine dihydroiodide, and hydriodic acid, 4% each; potassium iodate, resublimed iodine, sodium iodide, 1% each; and other inorganic compounds, 15%.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014**[e] |
|---|---|---|---|---|---|
| Production | W | W | W | W | W |
| Imports for consumption, crude content | 5,710 | 6,590 | 5,960 | 5,960 | 5,340 |
| Exports | 1,070 | 900 | 1,040 | 1,150 | 1,010 |
| Consumption: | | | | | |
| Apparent | W | W | W | W | W |
| Reported | 4,640 | 4,740 | 4,880 | 4,020 | 3,980 |
| Price, average c.i.f. value, dollars per kilogram, crude | 24.39 | 38.13 | 41.97 | 42.51 | 38.44 |
| Employment, number[e] | 30 | 30 | 30 | 30 | 40 |
| Net import reliance[1] as a percentage of reported consumption | 100 | 100 | 100 | 100 | 100 |

**Recycling:** Small amounts of iodine were recycled, but no data were reported.

**Import Sources (2010–13):** Chile, 87%; Japan, 12%; and other, 1%.

| **Tariff:** **Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| Iodine, crude | 2801.20.0000 | Free. |
| Iodide, calcium or copper | 2827.60.1000 | Free. |
| Iodide, potassium | 2827.60.2000 | 2.8% ad val. |
| Iodides and iodide oxides, other | 2827.60.5100 | 4.2% ad val. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **Désirée E. Polyak [(703) 648–4909, dpolyak@usgs.gov]**

# IODINE

**Events, Trends, and Issues:** The 2014 iodine price decreased from the historically high levels of 2012 and early 2013. Iodine prices steadily declined throughout 2014. Spot prices of iodine crystal, according to Industrial Minerals, averaged around $50 per kilogram at the beginning of 2014 and decreased continuously to an average of around $37 per kilogram in September 2014. According to industry sources, the decline in prices was attributed to the decrease in demand from downstream specialty chemical consumers combined with a faster than anticipated rampup of production by suppliers in Chile. Owing to the price decreases, some producers, most notably in Chile, have announced temporary reduction of iodine production.

As in recent years, Chile was the world's leading producer of iodine, followed by Japan and the United States. Chile accounted for more than 66% of world production in 2014, having two of the leading iodine producers in the world. The Chilean producers were operating close to capacity and were expected to adjust production in response to changes in demand.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[2] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | W | W | 250,000 |
| Azerbaijan | 350 | 350 | 170,000 |
| Chile | 20,700 | 21,000 | 1,800,000 |
| China | NA | NA | 4,000 |
| Indonesia | 75 | 75 | 100,000 |
| Japan | 9,500 | 9,500 | 5,000,000 |
| Russia | 200 | 200 | 120,000 |
| Turkmenistan | 500 | 500 | 70,000 |
| World total (rounded) | [3]31,300 | [3]31,600 | 7,500,000 |

**World Resources:** In addition to the reserves shown above, seawater contains 0.06 parts per million iodine, or approximately 90 billion tons. 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, nitrate, and oil, the seaweed industry represented a major source of iodine prior to 1959 and remains a large resource.

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

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]Defined as imports – exports + adjustments for Government and industry stock changes.
[2]See Appendix C for resource/reserve definitions and information concerning data sources.
[3]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 2014 with an estimated value of about $113 billion. Pig iron was produced by 4 companies operating integrated steel mills in 11 locations. About 59 companies produce raw steel at about 113 minimills. Combined production capability was about 114 million tons. Indiana accounted for 25% of total raw steel production, followed by Ohio, 13%; Michigan, 6%; and Pennsylvania, 6%. The distribution of steel shipments was estimated to be warehouses and steel service centers, 25%; construction, 18%; transportation (predominantly automotive), 16%; cans and containers, 2%; and other, 39%.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Pig iron production[2] | 26.8 | 30.2 | 30.1 | 30.3 | 29 |
| Steel production | 80.5 | 86.4 | 88.7 | 86.9 | 88 |
| Basic oxygen furnaces, percent | 38.7 | 39.7 | 40.9 | 39.4 | 37 |
| Electric arc furnaces, percent | 61.3 | 60.3 | 59.1 | 60.6 | 63 |
| Continuously cast steel, percent | 97.4 | 98.0 | 98.6 | 98.8 | 99 |
| Shipments: | | | | | |
| Steel mill products | 75.7 | 83.3 | 87.0 | 86.6 | 89 |
| 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 of steel mill products | 21.7 | 25.9 | 30.4 | 29.2 | 39 |
| Exports of steel mill products | 11.0 | 12.2 | 12.5 | 11.5 | 11 |
| Apparent steel consumption[4] | 80 | 90 | 98 | 100 | 102 |
| Producer price index for steel mill products (1982=100)[5] | 191.7 | 216.2 | 208.0 | 195.0 | 200 |
| Steel mill product stocks at service centers yearend[6] | 7.0 | 7.6 | 7.8 | 7.6 | 7 |
| Total employment, average, number | | | | | |
| Blast furnaces and steel mills | 137,000 | 148,000 | 152,000 | 149,000 | 149,000 |
| Iron and steel foundries[e] | 64,000 | 69,000[e] | 69,000[e] | 69,000[e] | 69,000 |
| Net import reliance[7] as a percentage of apparent consumption | 6 | 7 | 11 | 12 | 17 |

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

**Import Sources (2010–13):** Canada, 20%; Mexico, 10%; the Republic of Korea, 10%; Brazil, 10%; and other, 50%.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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.

Prepared by **Michael D. Fenton [(703) 648–4972, mfenton@usgs.gov]**

# IRON AND STEEL

**Events, Trends, and Issues:** The expansion or contraction of gross domestic product (GDP) may be considered a predictor of the health of the steelmaking and steel manufacturing industries, worldwide and domestically. The World Bank's (WB) forecast of global GDP growth for 2014, 2015, and 2016 was 2.8%, 3.4%, and 3.5%, respectively. The U.S. Federal Reserve's projections for the U.S. 2014 GDP growth rate was between 2.8% and 3.0%, between 3.0% and 3.2% for 2015, and between 2.5% and 3.0% for 2016. Manufacturing expanded in August 2014; the Institute of Supply Management's Purchasing Managers Index (PMI) registered 59%, which is the highest reading since March 2011 when the PMI registered 59.1%. PMI in excess of 43.2%, over a period of time generally indicates an expansion of the overall economy. Therefore, the August PMI indicates growth for the 63rd consecutive month in the overall economy, and indicates expansion in the manufacturing sector for the 15th consecutive month.

While the global economy struggled during 2009–13 to recover from the recession, the global steel industry, rather than consolidating and becoming more efficient, built more production capacity despite weak demand growth. An estimated 100 new mills are expected to be built by 2016. Much of this overcapacity was attributed to China, the world's leading steel producer, which accounted for about 49% of global output and had 6 of the world's 10 largest steelmakers. China's total estimated capacity reached about 1,025 Mt, with a net capacity addition of about 65 Mt in 2013, but operated at only about 76% of capacity in 2012. During 2013, China added at least 58 new steel-making furnaces. China had, during 2013, 35%–40% more steel-making capacity than it needed. This surplus steel has been exported to other steel-making countries, including the United States.

The International Energy Agency predicted that the United States could become the world's leading oil producer by 2020. As oil and gas production increases, so will the demand for steel pipe and tube used in drilling operations and transportation of products. A Mexico-based company is constructing a state-of-the-art steel mill at Bryan, TX, that will be producing about 270,000 metric tons of electric resistance welded pipe and tube for the oil and gas industry. The plant will employ 300 to 500 workers and is expected to result in increased employment in local trucking, machine shop, and coating service businesses. Also, a Dubai-based company is planning to build a $102 million plant in Buffalo, NY, that will make as much as 136,000 metric tons annually of high-grade alloy pipes.

**World Production:**

| | Pig iron | | Raw steel | |
|---|---|---|---|---|
| | 2013 | 2014[e] | 2013 | 2014[e] |
| United States | 30 | 29 | 87 | 88 |
| Brazil | 26 | 26 | 35 | 34 |
| China | 709 | 710 | 779 | 820 |
| France | 10 | 11 | 16 | 17 |
| Germany | 27 | 28 | 43 | 44 |
| India | 50 | 54 | 81 | 83 |
| Japan | 84 | 84 | 111 | 111 |
| Korea, Republic of | 41 | 47 | 81 | 65 |
| Russia | 51 | 51 | 69 | 71 |
| Ukraine | 29 | 25 | 33 | 26 |
| United Kingdom | 10 | 10 | 12 | 12 |
| Other countries | 113 | 119 | 273 | 274 |
| World total (rounded) | 1,180 | 1,190 | 1,620 | 1,650 |

**World Resources:** Not applicable. See Iron Ore.

**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 Ore and Iron and Steel Scrap.
[2]More than 95% of iron made is transported in molten form to steelmaking furnaces located at the same site.
[3]U.S. Census Bureau.
[4]Defined as steel shipments + imports - exports + adjustments for industry stock changes - semifinished steel product imports.
[5]U.S. Department of Labor, Bureau of Labor Statistics.
[6]Metals Service Center Institute.
[7]Defined as imports – exports + adjustments for Government and industry stock changes.

# IRON AND STEEL SCRAP[1]

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

**Domestic Production and Use:** 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 $26.1 billion in 2014, slightly less than that of 2013. U.S. apparent steel consumption, an indicator of economic growth, increased to about 108 million tons in 2014. Manufacturers of pig iron, raw steel, and steel castings accounted for about 88% 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 12% to produce cast iron and steel products, such as motor blocks, pipe, and machinery parts. Relatively small quantities of 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 2014, raw steel production was about 88 million tons, up slightly from that of 2013; annual steel mill capability utilization was about 78% compared with 77% for 2013. Net shipments of steel mill products were about 90 million tons, up 4.0% from those in 2013.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production: | | | | | |
| Home scrap | 10 | 10 | 10 | 8 | 8 |
| Purchased scrap[2] | 66 | 72 | 70 | 77 | 73 |
| Imports for consumption[3] | 4 | 4 | 4 | 4 | 4 |
| Exports[3] | 21 | 24 | 21 | 18 | 15 |
| Consumption, reported | 60 | 63 | 63 | 59 | 52 |
| Price, average, dollars per metric ton delivered, No. 1 Heavy Melting composite price, Iron Age Average, Pittsburgh, Philadelphia, Chicago | 319 | 392 | 360 | 341 | 352 |
| Stocks, consumer, yearend | 3.3 | 4.0 | 4.2 | 4.2 | 4.2 |
| Employment, dealers, brokers, processors, number[4] | 30,000 | 30,000 | 30,000 | 30,000 | 30,000 |
| Net import reliance[5] as a percentage of reported consumption | E | E | E | E | E |

**Recycling:** Recycled iron and steel scrap is a vital raw material for the production of new steel and cast iron products. The steel and foundry industries in the United States have been structured to recycle scrap, and, as a result, are highly dependent upon scrap.

In the United States, the primary source of old steel scrap was the automobile. The recycling rate for automobiles in 2013, the latest year for which statistics were available, was about 85%. In 2013, the automotive recycling industry recycled more than 14 million tons of steel from end-of-life vehicles through more than 300 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 2013 were 82% and 70%, respectively; this was the latest year for which statistics were available. Recycling rates for construction materials in 2013 were, as in 2012, about 98% for plates and beams and 72% for rebar and other materials. The recycling rates for appliance, can, and construction steel are expected to increase not only in the United States, but also 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.

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 59% post-consumer (old, obsolete) scrap, 23% prompt scrap (produced in steel-product manufacturing plants), and 18% home scrap (recirculating scrap from current operations).

**Import Sources (2010–13):** Canada, 79%; Mexico, 9%; United Kingdom, 4%; Sweden, 3%; and other, 5%.

Prepared by **Michael D. Fenton [(703) 648–4972, mfenton@usgs.gov]**

# IRON AND STEEL SCRAP

| **Tariff: Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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:** During 2014, hot-rolled steel prices decreased from $765 per ton in January to a low of $621 per ton in March and then increased to $628 per ton in November. Prices of hot-rolled steel ended the year slightly lower than those in 2013. The producer price index for steel mill products increased to 222 in May 2011 from 153 in May 2009 and then reached an estimated high of 202 in August 2014. Steel mill production capability utilization peaked at 80.9% in April 2012 from 40.8% in April 2009, decreased to a low for the year of 68% in October 2012, and then rose to 79.6% in July 2014. World steel consumption was expected to increase by 2.0% to 1.6 billion tons in 2014 and by 2.0% to 1.6 billion tons in 2015.

Scrap prices fluctuated during the first 9 months of 2014, between about $352 and $389 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 $370 per ton during the first 9 months of 2014. As reported by Scrap Price Bulletin, the average price for nickel-bearing stainless steel scrap delivered to purchasers in Pittsburgh was about $1,732 per ton during the first 11 months of 2014, which was about 15% higher than the 2013 average price of $1,511 per ton. Exports of ferrous scrap decreased in 2014 to an estimated 15 million tons from 18 million tons during 2013, mainly to Turkey, Taiwan, the Republic of Korea, and China, in descending order of export tonnage. The value of exported scrap decreased from $7.6 billion in 2013 to an estimated $6.3 billion in 2014.

During 2014, the U.S. ferrous scrap industry was adversely affected by the continuing global economic slow down, which began in December 2007; the devaluation of foreign currencies relative to the U.S. dollar; unusually harsh winter weather in the eastern half of the United States; and logistical restraints related to the development of new shale oil reserves in the United States. Countries that have been significant consumers of U.S. ferrous scrap continued to experience financial difficulties, showing no signs of recovering from the recession. Thus, demand for U.S. scrap was weak throughout 2014. Scrap exports during 2011 were at a high of about 24 million tons, whereas 2014 exports may be only an estimated 15 million tons. Policies of the U.S. Federal Reserve Bank, designed to improve the U.S. economy, caused devaluation of the currencies of many nations, such as Turkey, which has been the largest consumer of U.S. ferrous scrap exports in recent years. The strengthening of the U.S. dollar made sales of exported U.S. scrap difficult at other than discount prices. An early winter and unusually harsh winter conditions caused scrap dealers to experience slower than normal delivery of rail cars for their scrap. Also, the need to ship oil east from North Dakota because of the lack of pipelines diverted hundreds of locomotives that normally would have been used to haul scrap for export. The United States will likely continue exporting valuable ferrous scrap for at least another decade, and Turkey and the Republic of Korea will likely remain large importers of scrap at least through 2020.

**World Mine Production and Reserves:** Not applicable.

**World Resources:** Not applicable.

**Substitutes:** About 4.8 million tons of direct-reduced iron was used in the United States in 2014 as a substitute for iron and steel scrap, up from 4.5 million tons in 2013.

[e]Estimated. E Net exporter.

[1]See also Iron and Steel and Iron Ore.

[2]Receipts – shipments by consumers + exports – imports.

[3]Includes used rails for rerolling and other uses, and ships, boats, and other vessels for scrapping.

[4]Estimated, based on 2002 Census of Wholesale Trade for 2007 through 2012.

[5]Defined as imports – exports + adjustments for Government and industry stock changes.

# IRON AND STEEL SLAG

(Data in million metric tons unless otherwise noted)

**Domestic Production and Use:** Ferrous slags are produced during the making of iron and steel and, after cooling and processing, are sold primarily to the construction industry. Data on actual U.S. slag production are unavailable, but it is estimated to have been in the range of 16 to 22 million tons in 2014. Domestic slag sales[1] in 2014 amounted to an estimated 16 million tons, valued at about $270 million (f.o.b. plant). Iron (blast furnace) slag accounted for about 45% of the tonnage sold and had a value of about $210 million; nearly 85% of this value was from sales of granulated slag. Steel slag produced from basic oxygen and electric arc furnaces accounted for the remainder.[2] Slag was processed by about 25 companies servicing active iron and (or) steel facilities or reprocessing old slag piles at about 140 processing plants in 32 States; included in this tally are a number of facilities that grind and sell ground granulated blast furnace slag (GGBFS) based on imported unground feed.

The prices listed in the table below are weighted, but rounded, averages for iron and steel slags sold for a variety of applications. Actual prices per ton ranged widely in 2014, from nil to a few cents for some steel slags at a few locations to about $100 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. Virtually 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 by truck only over short distances, but rail and waterborne transportation allow greater distances. The much higher unit value of GGBFS likewise permits long distance transportation, including from overseas.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013[e]** | **2014[e]** |
|---|---|---|---|---|---|
| Production, marketed[1, 3] | 15.8 | 15.4 | 16.0 | 15.5 | 16.0 |
| Imports for consumption[4] | 1.4 | 1.6 | 1.2 | 1.3 | 1.3 |
| Exports | 0.1 | ([5]) | ([5]) | ([5]) | ([5]) |
| Consumption, apparent[4, 6] | 15.8 | 15.4 | 16.0 | 15.5 | 16.0 |
| Price average value, dollars per ton, f.o.b. plant[7] | 17.00 | 17.00 | 17.00 | 17.00 | 17.00 |
| Employment, number[e] | 2,100 | 2,000 | 1,800 | 1,700 | 1,700 |
| Net import reliance[8] as a percentage of apparent consumption | 8 | 9 | 7 | 8 | 8 |

**Recycling:** Slag is commonly 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, but data on metal returns are unavailable.

**Import Sources (2010–13):** Granulated blast furnace slag (mostly unground) is the dominant ferrous slag imported, but official import data in some years include significant tonnages of nonslag materials (such as cenospheres, fly ash, and silica fume) and slags or other residues of various metallurgical industries (such as copper slag) whose unit values are outside the range expected for granulated slag. The official data appear to have underreported the granulated slag imports in some recent years, but likely not in 2011–12. Based on official data, the principal country sources for 2010–13 were Canada, 38%; Japan, 35%; Spain, 7%; Italy, 6%, but likely underreported; and other, 14%.

**Tariff:**

| Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Granulated slag | 2618.00.0000 | Free. |
| Slag, dross, scale, from manufacture of iron and steel | 2619.00.3000 | Free. |

**Depletion Allowance:** Not applicable.

**Government Stockpile:** None.

Prepared by **Hendrik G. van Oss [(703) 648–7712, hvanoss@usgs.gov]**

# IRON AND STEEL SLAG

**Events, Trends, and Issues:** The availability of blast furnace slag is becoming problematic in the United States because of the closure and (or) continued idling of a number of active U.S. blast furnaces in recent years, the lack of construction of new furnaces, and the depletion of old slag piles. At yearend 2014, granulation cooling was available at only three active U.S. blast furnaces and was unlikely to be installed at any other sites. Pelletized blast furnace slag was in very limited supply (one site only), and it was uncertain if any additional pelletizing capacity was being planned. Basic oxygen furnace steel slags have become less available recently because of the closure of several integrated iron and steel complexes, thus, the long-term supply of steel slag will be increasingly reliant on electric arc furnaces. Where slag availability has not been a problem, slag (as aggregate) sales to the construction sector have sometimes been less volatile than those of natural aggregates. Domestic and import supply constraints appear to have limited U.S. demand for GGBFS in recent years, and sales have failed to match the relative volume and price 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 content. Recent draft regulations to restrict emissions of $CO_2$ and mercury by coal-fired power plants, together with the plant closures or switchover at many such plants to low-cost 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. This has the potential to increase future demand for GGBFS. Long-term growth in the supply of GGBFS will mainly depend on imports, either of ground or unground material. Imports may be constrained by increasing international demand for the same material and because not all granulated slag produced overseas is of high quality. New restrictions on mercury emissions by cement plants will likely 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 it is estimated that annual world iron slag output in 2014 was on the order of 310 to 370 million tons, and steel slag about 170 to 250 million tons, based on typical ratios of slag to crude iron and steel output.

**World Resources:** Not applicable.

**Substitutes:** Ferrous slags compete with crushed stone and sand and gravel as aggregates in the construction sector but are far less widely available than the natural materials. Fly ash, natural pozzolans, and silica fume are common alternatives to GGBFS as cementitious additives in blended cements and concrete, and in this respect also compete 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. Some other metallurgical slags, such as copper slag, can compete with ferrous slags in some specialty markets but are generally in much more restricted supply than ferrous slags.

[e]Estimated.
[1]Data are from an annual survey of slag processors and pertain to the quantities of processed slag sold rather than that processed or produced during the year. The data exclude any entrained metal that may be recovered during slag processing and returned to iron and, especially, steel furnaces, and 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 2010–14.
[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). Overall, actual production of blast furnace slag 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.
[4]Based on official (U.S. Census Bureau) data. Comparisons with unofficial import data suggest that the official data may have understated the true imports of granulated slag, at least prior to 2010, by amounts of up to about 1 million tons per year; the apparent underreporting was relatively small for 2011–12, but is estimated at 0.4 million tons in 2013. The U.S. Geological Survey canvass captures only part of the imported slag.
[5]Less than 0.05 million tons.
[6]Although definable as total sales of slag (including those from imported feed) minus exports, apparent consumption of slag does not significantly differ from total sales owing to the very small export tonnages.
[7]Rounded to the nearest $1.00 per metric ton; component data include a large proportion of estimates.
[8]Defined as total imports of slag minus exports of slag.

# IRON ORE[1]

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

**Domestic Production and Use:** In 2014, mines in Michigan and Minnesota shipped 93% of the usable iron ore products in the United States, with an estimated value of $5.1 billion. Twelve iron ore mines (9 open pits and 3 reclamation operations), 9 concentration plants, 10 pelletizing plants, 2 direct-reduced iron (DRI) plants, and 1 iron nugget plant operated during the year. Almost all ore was concentrated before shipment. Eight of the mines, operated by three companies, accounted for the majority of production. The United States was estimated to have produced and consumed 2% of the world's iron ore output.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production[2] | 49.9 | 54.7 | 54.0 | 53.0 | 57.5 |
| Shipments | 50.6 | 55.6 | 52.9 | 52.7 | 54.2 |
| Imports for consumption | 6.4 | 5.3 | 5.2 | 3.2 | 5.5 |
| Exports | 10.0 | 11.1 | 11.2 | 11.0 | 13.0 |
| Consumption: | | | | | |
| Reported (ore and total agglomerate)[3] | 42.3 | 46.3 | 46.9 | 48.8 | 49.5 |
| Apparent[4] | 47.9 | 49.1 | 48.1 | 47.1 | 47.8 |
| Price,[5] U.S. dollars per metric ton | 98.79 | 99.45 | 98.16 | 104.90 | 101.00 |
| Stocks, mine, dock, and consuming plant, yearend, excluding byproduct ore | 3.47 | 3.26 | 3.11 | 2.29 | 4.50 |
| Employment, mine, concentrating and pelletizing plant, number | 4,780 | 5,270 | 5,420 | 5,644 | 5,750 |
| Net import reliance[6] as a percentage of apparent consumption (iron in ore) | E | E | E | E | E |

**Recycling:** None (see Iron and Steel Scrap section).

**Import Sources (2010–13):** Canada, 71%; Brazil, 12%; Russia, 3.0%; Venezuela, 3.0%; and other, 11%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Concentrates | 2601.11.0030 | Free. |
| Coarse ores | 2601.11.0060 | Free. |
| Fine 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 expected to increase in 2014 and 2015 from that of 2013 owing to new production that began in late 2013 and 2014. In December 2013, one company in Louisiana began producing DRI pellets from imported iron ore concentrates. The facility was the largest of its kind in the world, with a 2.5 million-ton-per-year capacity, although equipment failure, upgrades, and repairs temporarily idled the plant periodically during the year. In September, Reynolds Pellet Plant began operations in Indiana using iron ore concentrates from Minnesota reclamation operations. The plant was designed to produce 3 million tons per year of high-quality flux pellets to feed blast furnaces in Ohio and Kentucky. Mesabi Chief Plant Four, a 2-million-ton-per-year iron ore reclamation plant, was set to begin operations in the first quarter of 2015.

In February, it was announced that the Empire Mine would remain open through January 2017 following an extension of supply and joint-operating agreements. Production rates reached 2 million tons per year for the Comstock Mountain Lion Mine in Utah, which produces concentrates for export. One company's project in Minnesota to construct a 7-million-ton-per-year open-pit iron ore mine, concentrator, pelletizing plant, and DRI plant was expected to begin in the second half of 2015 after receiving financing needed to complete the project. Construction began on a 2-million-ton-per-year DRI plant in Texas, expected to be operational by yearend 2015. Weather-related delays on the Great Lakes reduced shipments from January through April; however, record-high shipments of iron ore were recorded during the summer months.

Prepared by **Christopher A. Tuck [(703) 648–4912, ctuck@usgs.gov]**

# IRON ORE

Following the completion of several infrastructure improvement and capacity projects by the three largest iron ore miners in Western Australia, regional shipments increased to record levels. Additional projects in Australia were aimed at increasing capacity in 2015 and could put as much as 100 million tons of additional product on the market annually. Increased production in Australia and lower than expected consumption in China moved the market into oversupply. Spot market prices per dry metric ton of fines at 62% iron content fell to nearly $80 in October from a high of $154 in 2013. Global mine closures were attributed to sustained reductions in spot market prices.

In eastern Canada, the Wabush Scully Mine was closed and the Pointe-Noire Pellet Plant was idled indefinitely, which could lead to increased domestic exports to Canada in 2014. Three mines in Australia were closed or idled in late 2014. An estimated 20% to 30% of iron mines in China were closed or idled in 2014. Production, by iron content, of iron ore in China was estimated to decline by 16% to 310 million tons in 2014 and projected to decline to 275 million tons in 2015. China's Ministry of Industry Information and Technology announced they would close an additional 19 million tons per year of iron ore capacity and 29 million tons per year of steelmaking capacity by yearend 2014.

**World Mine Production and Reserves:** Mine production for China is based on crude ore, rather than usable ore, which is reported for the other countries.

| | Mine production | | Reserves[7] | |
|---|---|---|---|---|
| | 2013 | 2014[e] | Crude ore | Iron content |
| United States | 53 | 58 | 6,900 | 2,100 |
| Australia | 609 | 660 | 53,000 | 23,000 |
| Brazil | 317 | 320 | 31,000 | 16,000 |
| Canada | 43 | 41 | 6,300 | 2,300 |
| China | 1,450 | 1,500 | 23,000 | 7,200 |
| India | 150 | 150 | 8,100 | 5,200 |
| Iran | 50 | 45 | 2,500 | 1,400 |
| Kazakhstan | 26 | 26 | 2,500 | 900 |
| Russia | 105 | 105 | 25,000 | 14,000 |
| South Africa | 72 | 78 | 1,000 | 650 |
| Sweden | 26 | 26 | 3,500 | 2,200 |
| Ukraine | 82 | 82 | [8]6,500 | [8]2,300 |
| Other countries | 127 | 131 | 18,000 | 9,500 |
| World total (rounded) | 3,110 | 3,220 | 190,000 | 87,000 |

**World Resources:** U.S. resources are estimated to be about 27 billion tons of iron contained within 110 billion tons of iron ore. 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 exceed 230 billion tons of iron contained within greater than 800 billion tons of crude ore.

**Substitutes:** The only source of primary iron is iron ore, used directly as direct-shipping ore or converted to briquettes, concentrates, DRI, iron nuggets, sinter, or pellets. At some blast furnace operations, ferrous scrap may constitute as much as 7% of the blast furnace feedstock. Scrap, DRI, and iron nuggets are extensively used for steelmaking in electric arc furnaces and in iron and steel foundries, but scrap availability can be limited. Technological advancements have been made, which allow hematite to be recovered from tailings basins and pelletized.

[e]Estimated. E Net exporter.
[1]See also Iron and Steel and Iron and Steel Scrap.
[2]Includes agglomerates, concentrates, DRI, direct-shipping ore, iron nuggets, pellets, and byproduct ore for consumption.
[3]Includes weight of lime, flue dust, and other additives in sinter and pellets for blast furnaces.
[4]Defined as production + imports – exports + adjustments for industry stock changes.
[5]Estimated from reported value of ore at mines.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]See Appendix C for resource/reserve definitions and information concerning data sources.
[8]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) are mined by two companies in two States in the United States. Production, which was withheld by the U.S. Geological Survey to avoid disclosing company proprietary data, decreased slightly in 2014 from that of 2013. Six companies, including the two producers of natural IOPs, processed and sold about 49,000 tons of finished natural and synthetic IOPs at an estimated value of $80 million. Although sales by those companies increased by about 4% in 2014 from those of 2013, they remained well below the sales peak of 88,100 tons in 2007. About 60% of natural and synthetic finished IOPs were used in concrete and other construction materials, 25% in coatings and paints, 5% in foundry uses, and more than 2% each in animal food, industrial chemicals, magnetic ink and tape, and other uses.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, mine | W | W | W | W | W |
| Production, finished natural and synthetic IOP | 54,700 | 48,000 | 48,400 | 47,200 | 49,000 |
| Imports for consumption | 151,000 | 158,000 | 151,000 | 165,000 | 170,000 |
| Exports, pigment grade | 8,750 | 8,660 | 8,950 | 8,170 | 8,900 |
| Consumption, apparent[1] | 197,000 | 197,000 | 190,000 | 204,000 | 210,000 |
| Price, average value, dollars per kilogram[2] | 1.48 | 1.54 | 1.61 | 1.60 | 1.60 |
| Employment, mine and mill | 60 | 58 | 58 | 58 | 60 |
| Net import reliance[3] as a percentage of apparent consumption | >50% | >50% | >50% | >50% | >50% |

**Recycling:** None.

**Import Sources (2010–13):** Natural: Cyprus, 77%; Austria and Germany, 6% each; Spain, 5%; and other, 6%. Synthetic: China, 51%; Germany, 26%; Brazil and Canada, 7% each; and other, 9%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Natural: | | |
| Micaceous iron oxides | 2530.90.2000 | 2.9% ad val. |
| Earth colors | 2530.90.8015 | Free. |
| Iron oxides and hydroxides containing more than 70% $Fe_2O_3$: | | |
| 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 2014, domestic production and sales of crude natural IOPs decreased slightly for the second year. In Europe, consumption of IOPs declined, mostly owing to continued sluggishness in the region's construction industry; moderate to strong growth continued in Asia. Domestically, residential construction, in which IOPs are commonly used to color concrete block and brick, ready-mixed concrete, and roofing tiles, increased in the first half of 2014. Housing starts and completions each rose by about 7% and 15%, respectively, compared with those of the same period in 2013, and increases were expected to continue in 2015.

Spending on residential construction increased by more than 7% during the first 8 months of 2014 compared with the same period in 2013. Spending on nonresidential construction, which accounted for about 62% of construction expenditures, increased by 6% in the first 8 months of 2014 compared with the same period in 2013. Increased residential and nonresidential construction could lead to an increase in IOP consumption in this sector.

Prepared by **Arnold O. Tanner [(703) 648–4791, atanner@usgs.gov]**

# IRON OXIDE PIGMENTS

Exports of pigment-grade IOPs increased by 9% during 2014 compared with those of 2013, with exports going to a variety of countries. Exports of other grades of IOPs and hydroxides increased by 8% during 2014 compared with 2013, mostly owing to a substantial increase in exports to China and Spain and smaller increases to Australia, Germany, Israel, and Thailand. Total imports of natural and synthetic IOPs increased slightly during 2014 compared with those in 2013.

A Texas-based specialty chemical company completed the purchase of a major pigment producer with iron oxide pigment facilities in California, Georgia, Maryland, Missouri, and Pennsylvania.

A company in Utah began production of a high-purity “advanced natural” ”iron oxide, mostly composed of goethite and hematite. The company intended to compete in synthetic and natural IOP markets.

Three leading producers of finished natural and synthetic IOPs continued construction of synthetic IOP production plants in Augusta, GA; Anhui, China; and Ningbo, China. The startup of the advanced technology facility in Georgia—the first new IOP production plant built in the United States in nearly 35 years—was expected to begin early in 2015. The plants in China, one owned by a Hong Kong-based company and the other owned by a German chemical company, had similar timelines for startup.

**World Mine Production and Reserves:** The reserves data for India were revised based on information reported by the Government of India.

| | Mine production | | Reserves[4] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | W | W | Moderate |
| Austria (micaceous IOP) | 3,500 | 4,200 | NA |
| Cyprus (umber) | 4,000 | 4,100 | Moderate |
| France | 18,000 | 18,000 | NA |
| Germany[5] | 205,000 | 210,000 | Moderate |
| India (ochre) | 1,400,000 | 1,400,000 | 55,000,000 |
| Pakistan | 45,000 | 45,000 | Moderate |
| Spain | 16,400 | 17,000 | 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:** IOPs are probably the most commonly used of the natural minerals suitable for use as pigments after milling. 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 the limited tonnages available. 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 several 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 production of finished natural and synthetic IOPs + imports – exports.
[2]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/reserve definitions and information concerning data sources.
[5]Includes natural and synthetic iron oxide pigment.
[6]A significant number of other countries are thought to produce IOPs, but output is not reported and no basis is available to formulate estimates of output levels, which likely is substantial. Such countries include Azerbaijan, China, Honduras, Kazakhstan, Russia, Turkey, and Ukraine.

# KYANITE AND RELATED MINERALS

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** One firm in Virginia with integrated mining and processing operations produced kyanite from two hard-rock open pit mines and mullite by calcining kyanite. Another company produced synthetic mullite in Georgia from materials mined from two domestic sites, one in Alabama and the other in Georgia. Commercially produced synthetic mullite is made by sintering or fusing such feedstock materials as kyanite 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 used 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 in North Carolina as part of a mineral mixture of high-purity silica and alumina for use in a variety of refractory mineral products for the foundry and ceramics industries.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine[1] | 93 | 98 | 99 | 110 | 100 |
| Synthetic mullite[e] | 40 | 40 | 40 | 40 | 50 |
| Imports for consumption (andalusite) | 2 | 5 | 3 | 4 | 3 |
| Exports | 38 | 38 | 36 | 42 | 38 |
| Consumption, apparent[e] | 97 | 105 | 105 | 112 | 115 |
| Price, average, dollars per metric ton:[2] | | | | | |
| U.S. kyanite, raw concentrate | 283 | 335 | 340 | 300 | 310 |
| U.S. kyanite, calcined | 422 | 503 | 513 | 448 | 460 |
| Andalusite, Transvaal, South Africa | 336 | 300 | 300 | 348 | 350 |
| Employment, kyanite mine, office, and plant, number[3, e] | 115 | 120 | 125 | 135 | 150 |
| Employment, mullite plant, office, and plant, number[3, e] | 170 | 180 | 200 | 205 | 210 |
| Net import reliance[4] as a percentage of apparent consumption | E | E | E | E | E |

**Recycling:** Insignificant.

**Import Sources (2010–13):** South Africa, 79%; France, 9%; Peru, 9%; and other, 3%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Andalusite, kyanite, and sillimanite | 2508.50.0000 | Free. |
| Mullite | 2508.60.0000 | Free. |

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

**Government Stockpile:** None.

**Events, Trends, and Issues:** Crude steel production in the United States, which ranked third in the world, increased by 1.5% in the first 8 months of 2014 compared with that of the same period in 2013, indicating a potential increase in consumption of kyanite-mullite refractories if the trend continues. Mostly as the result of increases in steel production in Asia, total world steel production rose by 3.7% during the first 8 months of 2014 compared with 2.9% in the same period in 2013. Of the total world refractories market, estimated to be approximately 40 million metric tons, crude steel manufacturing consumed more than 70% of refractories production.

Slow growth in world steel production during 2014 was, in part, the result of a sluggish economy in Western Europe and slower-than-expected economic growth in Eastern Europe and the United States. With steel production continuing to expand in Asia, andalusite and mullite could receive increasing consideration as alternative aluminosilicate refractory minerals to refractory bauxite owing to a continuing lack of readily available, inexpensive refractory-grade bauxite from China, which accounted for about three-quarters of market share worldwide.

Prepared by **Arnold O. Tanner [(703) 648–4791, atanner@usgs.gov]**

# KYANITE AND RELATED MINERALS

China is expected to continue to be the largest market for refractories, comprising the majority of global demand. Slowing, but still above-average, growth is expected in India. Eastern Europe, North America, and Western Europe are expected to continue to have significant refractory demand because of their large industrial bases. North America and Western Europe are expected to continue to increase slowly in the near term with recovery in manufacturing and steel production, but may lag behind the worldwide average in the longer term with steel production increasing in and shifting to less-developed countries. Demand for refractories in iron and steel production is expected to have greater 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.

Andalusite projects in Peru progressed. One facility increased production capacity by 50% and planned an increase of nearly as much for 2015. Exploration continued at another deposit and development of a processing operation was planned with production to begin in 2016. Large resources of kyanite were discovered in the far northwest region of Russia.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States[e] | 110 | 100 | Large |
| France | 70 | 70 | NA |
| India | 63 | 65 | 1,600 |
| South Africa | 220 | 170 | NA |
| Other countries | 1 | 15 | NA |
| World total (rounded) | 464 | 420 | 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 economical 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, in Brazil and India; and sillimanite, 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.
[1]Source: Virginia Department of Mines, Minerals and Energy.
[2]Source: Average of prices reported in Industrial Minerals.
[3]Includes mine, mill, and office employment. Source: Mine Safety and Health Administration.
[4]Defined as imports – exports.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.

# LEAD

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

**Domestic Production and Use:** The value of recoverable mined lead in 2014, based on the average North American Market price, was about $827 million. Six lead mines in Missouri, plus four mines in Alaska and Idaho that produced lead as a coproduct, accounted for all domestic mine production. Of the plants that produced secondary lead at yearend 2014, 12 plants having capacities of at least 30,000 tons per year of refined lead accounted for more than 95% of secondary production. Lead was consumed at more than 70 manufacturing plants. The lead-acid battery industry accounted for about 90% of the reported U.S. lead consumption during 2014. Lead-acid batteries were primarily used as starting-lighting-ignition (SLI) batteries for automobiles and trucks and as industrial-type batteries for standby power for computer and telecommunications networks and for motive power. During the first 9 months of 2014, 93.5 million lead-acid automotive batteries were shipped by North American producers, a slight increase from those shipped in the same period of 2013.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine, lead in concentrates | 369 | 342 | 345 | 340 | 355 |
| Primary refinery | 115 | 118 | 111 | 114 | 1 |
| Secondary refinery, old scrap | 1,140 | 1,130 | 1,110 | 1,150 | 1,150 |
| Imports for consumption: | | | | | |
| Lead in concentrates | ([1]) | ([1]) | ([1]) | ([1]) | ([1]) |
| Refined metal, wrought and unwrought | 273 | 316 | 351 | 487 | 550 |
| Exports: | | | | | |
| Lead in concentrates | 299 | 223 | 214 | 210 | 300 |
| Refined metal, wrought and unwrought | 85 | 47 | 53 | 48 | 55 |
| Consumption: | | | | | |
| Reported | 1,430 | 1,410 | 1,350 | 1,390 | 1,350 |
| Apparent[2] | 1,440 | 1,540 | 1,500 | 1,700 | 1,660 |
| Price, average, cents per pound: | | | | | |
| North American Producer | 109 | 122 | 114 | 115 | NA |
| North American Market | NA | NA | NA | NA | 107 |
| London Metal Exchange | 97.4 | 109 | 93.5 | 97.2 | 86 |
| Stocks, metal, producers, consumers, yearend | 65 | 48 | 72 | 70 | 60 |
| Employment: | | | | | |
| Mine and mill (average), number[3] | 1,590 | 1,700 | 1,660 | 1,690 | 1,650 |
| Primary smelter, refineries | 290 | 290 | 290 | 290 | 75 |
| Secondary smelters, refineries | 1,600 | 1,600 | 1,700 | 1,700 | 1,700 |
| Net import reliance[4] as a percentage of apparent consumption | 13 | 19 | 18 | 26 | 30 |

**Recycling:** In 2014, about 1.15 million tons of secondary lead was produced, an amount equivalent to 70% of apparent domestic lead consumption. Nearly all secondary lead was recovered from old (post-consumer) scrap at secondary smelters.

**Import Sources (2010–13):** Metal, wrought and unwrought: Canada, 68%; Mexico, 18%; Australia, 5%; and other, 9%.

| **Tariff:** Item | Number | Normal Trade Relations[5] 12–31–14 |
|---|---|---|
| Unwrought (refined) | 7801.10.0000 | 2.5% ad val. |
| Antimonial lead | 7801.91.0000 | 2.5% ad val. |
| Alloys of lead | 7801.99.9030 | 2.5% ad val. |

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

**Government Stockpile:** None.

**Events, Trends, and Issues:** Lead stocks held in global London Metal Exchange (LME) warehouses increased to 226,550 tons by the end of October from 213,950 tons at yearend 2013. LME stocks held in domestic warehouses declined to 725 tons from 2,175 tons during that time period. LME lead cash prices averaged $2,148 per metric ton in January, peaked at $2,236 in August, and declined to $2,037 per metric ton in October. Domestic mine production in 2014 increased from that in the previous year owing to increases in all of the lead-producing States.

Prepared by **David E. Guberman [(703) 648–4977, dguberman@usgs.gov]**

# LEAD

The Herculaneum, Missouri lead smelter, the only domestic primary lead smelter, closed at yearend 2013, per an agreement with the U.S. Environmental Protection Agency. In 2014, the plant processed a small amount of residual lead during demolition of the site. Following closure, the owner exported concentrates produced at its six mines in Missouri, contributing to the increase in lead exports in 2014. Most of the increase in refined lead imports in 2014 was attributable to the loss of domestic primary production; it was thought that some of the imports were held by traders.

In 2014, total secondary lead production in the United States was expected to be essentially unchanged from that in 2013. Increased production at a couple of secondary smelters was expected to be offset by temporary closure of one smelter. In mid-March, a producer temporarily shut down operations of a lead smelter in Vernon, CA (90,000-metric-ton-per-year capacity) owing to environmental concerns from State regulators. The company was making required improvements to the plant and intended to restart operations in 2015.

Increased exports of spent lead-acid batteries during the past few years (the majority of which went to Mexico) have reduced the amount of scrap available to secondary smelters. During the first 9 months of the year, 22.4 million spent SLI lead-acid batteries, containing an estimated 220,000 tons of lead, were exported.

Global mine production of lead was expected to be about 5.50 million tons in 2014, with production increases in Australia, China, and the United States. The International Lead and Zinc Study Group (ILZSG) forecast global refined lead production to increase slightly from that in 2013, to 11.3 million tons, primarily driven by increases in Australia, Belgium, China, India, Italy, and the Republic of Korea. ILZSG projected global lead consumption to increase slightly in 2014 from that in 2013, to 11.3 million tons, partially owing to an increase in China, and that global refined lead production would exceed consumption by 38,000 tons.

**World Mine Production and Reserves:** Reserves estimates for Australia, Canada, and Peru were revised based on information from Government and industry sources.

| | Mine production | | Reserves[6] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 340 | 355 | 5,000 |
| Australia | 711 | 720 | 35,000 |
| Bolivia | 82 | 75 | 1,600 |
| Canada | 20 | 4 | 247 |
| China | 2,900 | 2,950 | 14,000 |
| India | 106 | 110 | 2,600 |
| Ireland | 51 | 40 | 600 |
| Mexico | 210 | 220 | 5,600 |
| Peru | 266 | 270 | 7,000 |
| Poland | 90 | 40 | 1,700 |
| Russia | 195 | 195 | 9,200 |
| South Africa | 53 | 27 | 300 |
| Sweden | 62 | 62 | 1,100 |
| Turkey | 78 | 65 | NA |
| Other countries | 324 | 324 | 3,000 |
| World total (rounded) | 5,490 | 5,460 | 87,000 |

**World Resources:** Identified world lead resources total more than 2 billion tons. In recent years, significant lead resources have been demonstrated 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 of plastics has reduced the use of lead in cable covering and cans. Tin has replaced lead in solder for potable water systems. In the electronics industry, there has been a move toward lead-free solders and flat panel displays that do not require lead shielding. Steel and zinc are common substitutes for lead in wheel weights.

[e]Estimated. NA Not available.
[1]Less than ½ unit.
[2]Defined as primary refined production + secondary refined production + refined imports – refined exports + adjustments for Government and industry stock changes.
[3]Includes lead and zinc-lead mines for which lead was either a principal product or significant byproduct.
[4]Defined as imports – exports + adjustments for Government and industry stock changes; includes trade in refined lead.
[5]No tariff for Canada, Mexico, and Peru for item shown.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

# LIME[1]

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** In 2014, an estimated 19 million tons (21 million short tons) of quicklime and hydrate was produced (excluding commercial hydrators), valued at about $2.2 billion. At yearend, 31 companies were producing lime, which included 20 companies with commercial sales and 11 companies that produced lime strictly for internal use (for example, sugar companies). These companies had 76 primary lime plants (plants operating lime kilns) in 29 States and Puerto Rico. The 4 leading U.S. lime companies produced quicklime or hydrate in 24 States and accounted for about 75% of U.S. lime production. Principal producing States were, in descending order of production, Missouri, Kentucky, Alabama, Ohio, and Texas. Major markets for lime were, in descending order of consumption, steelmaking, flue gas desulfurization, water treatment, construction, mining, paper and pulp, and precipitated calcium carbonate.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production[2] | 18,300 | 19,100 | 18,800 | 19,200 | 19,000 |
| Imports for consumption | 445 | 512 | 468 | 394 | 380 |
| Exports | 215 | 231 | 212 | 270 | 270 |
| Consumption, apparent[3] | 18,500 | 19,400 | 19,100 | 19,300 | 19,100 |
| Quicklime average value, dollars per ton at plant | 103.70 | 107.90 | 115.40 | 117.80 | 116.00 |
| Hydrate average value, dollars per ton at plant | 124.70 | 130.90 | 136.90 | 140.60 | 139.00 |
| Employment, mine and plant, number | 5,000 | 5,100 | 5,100 | 5,100 | 5,100 |
| Net import reliance[4] 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 (2010–13):** Canada, 94%; Mexico, 5%; and other, 1%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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 2014, domestic lime production was expected to decrease slightly, owing to decreased consumption by the nonferrous metallurgical industry (primarily gold). As a result, national lime prices decreased slightly compared with those in 2013.

One company based in St. Louis, MO, acquired another lime producer in Huron, OH. Companies continued with construction projects in Pennsylvania and Virginia, which involved installation of new natural-gas-fired vertical-shaft kilns. Low interest rates and low energy prices have provided opportunities for lime companies to add new capacity or replace existing old capacity with natural-gas-fired kilns. Plans were underway in 2014 to construct a new, more energy-efficient lime plant in Florida. The new Florida plant, expected to become operational in 2015, would consist of two vertical kilns that are designed to consume much less fuel using multiple energy sources, including biomass, coal, lignite, natural gas, and petroleum coke.

Prepared by **Lisa A. Corathers [(703) 648–4973, lcorathers@usgs.gov]**

# LIME

**World Lime Production and Limestone Reserves:** Lime production data for the Republic of Korea is no longer reported, as information is inadequate on which to formulate reliable estimates of output.

| | Production | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 19,200 | 19,000 | Adequate for all countries listed. |
| Australia | 2,100 | 2,100 | |
| Belgium | 2,400 | 2,500 | |
| Brazil | 8,350 | 8,300 | |
| Bulgaria | 1,400 | 1,700 | |
| Canada | 1,800 | 1,900 | |
| China | 230,000 | 230,000 | |
| France | 3,900 | 4,000 | |
| Germany | 6,700 | 6,800 | |
| India | 16,000 | 16,000 | |
| Iran | 2,800 | 3,000 | |
| Italy[6] | 6,200 | 6,300 | |
| Japan (quicklime only) | 7,600 | 7,600 | |
| Poland | 1,670 | 1,800 | |
| Romania | 2,000 | 2,000 | |
| Russia | 10,800 | 11,000 | |
| Slovenia | 1,400 | 1,400 | |
| South Africa (sales) | 1,300 | 1,300 | |
| Spain | 1,900 | 1,900 | |
| Turkey (sales) | 4,500 | 4,500 | |
| Ukraine | 4,200 | 3,600 | |
| United Kingdom | 1,500 | 1,600 | |
| Vietnam | 1,500 | 1,500 | |
| Other countries | 14,100 | 15,000 | |
| World total (rounded) | 353,000 | 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.
[1]Data are for quicklime, hydrated lime, and refractory dead-burned dolomite. Includes Puerto Rico.
[2]Sold or used by producers.
[3]Includes some double counting based on nominal, undifferentiated reporting of company export sales as U.S. production.
[4]Defined as imports – exports.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]Includes hydraulic lime.

# LITHIUM

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

**Domestic Production and Use:** The only lithium mine operating in the United States was a brine operation in Nevada. Two companies produced a large array of downstream lithium compounds in the United States from domestic or South American lithium carbonate, lithium chloride, and lithium hydroxide. Domestic production was not published to protect proprietary data. A U.S. recycling company produced a small quantity of lithium carbonate from solutions recovered during the recycling of lithium-ion batteries.

Although lithium markets vary by location, global end-use markets are estimated as follows: ceramics and glass, 35%; batteries, 31%; lubricating greases, 8%; continuous casting mold flux powders, 6%; air treatment, 5%; polymer production, 5%; primary aluminum production, 1%; 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 worldwide.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production | W | W | W | [1]870 | W |
| Imports for consumption | 1,960 | 2,850 | 2,760 | 2,210 | 2,100 |
| Exports | 1,410 | 1,310 | 1,300 | 1,230 | 1,300 |
| Consumption: | | | | | |
| Apparent | W | W | W | W | W |
| Estimated | 1,100 | [2]2,000 | [2]2,000 | 1,800 | [2]2,000 |
| Price, annual average, battery-grade lithium carbonate, dollars per metric ton[3] | 5,180 | 5,180 | 6,060 | 6,800 | 6,600 |
| Employment, mine and mill, number | 70 | 70 | 70 | 70 | 70 |
| Net import reliance[4] as a percentage of apparent consumption | >50% | >80% | >60% | >50% | >50% |

**Recycling:** Historically, lithium recycling has been insignificant but has increased steadily owing to the growth in consumption of lithium batteries. One U.S. 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 the company $9.5 million to construct the first U.S. recycling facility for lithium-ion batteries, which was still under construction in 2014.

**Import Sources (2010–13):** Chile, 50%; Argentina, 46%; China, 3%; and other, 1%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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.P. grade | 2836.91.0010 | 3.7% ad val. |
| Other | 2836.91.0050 | 3.7% ad val. |

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

**Government Stockpile:** None.

**Events, Trends, and Issues:** Worldwide lithium production increased by about 6% in 2014. Production from Argentina and Chile increased approximately 15% each in response to increased lithium demand for battery applications. Also, in 2013, weather-related complications had reduced production for Argentina's major lithium producer. Lithium production in Australia and China also increased. Major lithium producers expected worldwide consumption of lithium in 2014 to be approximately 33,000 tons, an increase of 10% from that of 2013. Despite the increased lithium demand in 2014, worldwide lithium prices, on average, remained unchanged owing to the near balanced increase in worldwide lithium consumption and supply. Industrial Minerals reported a slight decrease in United States lithium carbonate prices.

In the late 1990s, subsurface brines became the dominant raw material for lithium carbonate production worldwide because of lower production costs compared with the mining and processing of hard-rock ores. Owing to growing lithium demand from China in the past several years, however, mineral-sourced lithium regained market share and was estimated to account for one-half of the world's lithium supply in 2014. Two brine operations in Chile and a spodumene operation in Australia accounted for the majority of world production. Argentina produced lithium

Prepared by **Brian W. Jaskula [(703) 648–4908, bjaskula@usgs.gov]**

# LITHIUM

carbonate and lithium chloride from brines. China produced lithium carbonate, lithium chloride, and lithium hydroxide from domestic brines and, increasingly, domestic and imported spodumene. In the United States, the brine operation in Nevada doubled production capacity in 2013. A new brine operation in Argentina was expected to be commissioned by yearend 2014.

Recent years have seen consolidation among the handful of major lithium producers. In 2013, China's leading lithium chemical producer acquired Australia's leading spodumene producing facility, having a capacity of 110,000 tons per year of lithium carbonate equivalent. In 2014, the United States-based parent company of one of Chile's brine operations acquired 49% of the Australian spodumene operation from the Chinese chemical producer, and effectively became the world's leading lithium producer. Later in 2014, a U.S. bromine products manufacturer agreed to purchase the U.S. lithium producer for $6.2 billion to create one of the world's largest speciality chemicals businesses.

Lithium supply security has become a top priority for Asian technology companies. Strategic alliances and joint ventures have been, and are continuing to be, established with lithium exploration companies to ensure a reliable, diversified supply of lithium for Asia's battery suppliers and vehicle manufacturers. Several brine operations were under development in Argentina, Bolivia, and Chile; spodumene mining operations were under development in Australia, Canada, China, and Finland; and a jadarite mining operation was under development in Serbia. Additional exploration for lithium continued, with numerous claims having been leased or staked worldwide.

Rechargeable batteries was the largest potential growth area for lithium compounds. Demand for rechargeable lithium batteries exceeds that of other rechargeable batteries. Automobile companies were developing lithium batteries for electric and hybrid electric vehicles. A leading electric car manufacturer announced plans to construct an immense lithium-ion battery plant in the United States capable of producing up to 500,000 lithium-ion vehicle batteries per year by 2020. The plant was expected to be vertically integrated, capable of producing finished battery packs directly from raw materials.

**World Mine Production and Reserves:** The reserves estimates for Australia and Brazil have been revised based on new information from Government and industry sources.

| | Mine production | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 870 | W | 38,000 |
| Argentina | 2,500 | 2,900 | 850,000 |
| Australia | 12,700 | 13,000 | 1,500,000 |
| Brazil | 400 | 400 | 48,000 |
| Chile | 11,200 | 12,900 | 7,500,000 |
| China | 4,700 | 5,000 | 3,500,000 |
| Portugal | 570 | 570 | 60,000 |
| Zimbabwe | 1,000 | 1,000 | 23,000 |
| World total (rounded) | 34,000 | [6]36,000 | 13,500,000 |

**World Resources:** Identified lithium resources in the United States total 5.5 million tons and approximately 34 million tons in other countries. Identified lithium resources for Bolivia and Chile are 9 million tons and more than 7.5 million tons, respectively. Identified lithium resources for major producing countries are: Argentina, 6.5 million tons; Australia, 1.7 million tons; and China, 5.4 million tons. In addition, Canada, Congo (Kinshasa), Russia, and Serbia have resources of approximately 1 million tons each. Identified lithium resources for Brazil total 180,000 tons.

**Substitutes:** Substitution for lithium compounds is possible in batteries, ceramics, greases, and manufactured glass. Examples are calcium and aluminum soaps as substitutes for stearates in greases; calcium, magnesium, mercury, and zinc as anode material in primary batteries; and sodic and potassic fluxes in ceramics and glass manufacture. Lithium carbonate is not considered to be an essential ingredient in aluminum potlines. Substitutes for aluminum-lithium alloys in structural materials are composite materials consisting of boron, glass, or polymer fibers in resins.

[e]Estimated. W Withheld to avoid disclosing company proprietary data.
[1]Source: Rockwood Holdings, Inc., 2013 annual report: Princeton, NJ, Rockwood Holdings, Inc., p. 16.
[2]Rounded to one significant figure to avoid disclosing company proprietary data.
[3]Source: Industrial Minerals, IM prices: Lithium carbonate, large contracts, delivered continental United States, annual average.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]Excludes U.S. production.

# MAGNESIUM COMPOUNDS[1]

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

**Domestic Production and Use:** Seawater and natural brines accounted for about 69% of U.S. magnesium compounds production in 2014. Magnesium compound production was valued at $251 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, and olivine was mined by one company in Washington. About 52% of the magnesium compounds consumed in the United States was used in agricultural, chemical, construction, environmental, and industrial applications. The remaining 48% was used for refractories.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production | 261 | 306 | 244 | 297 | 320 |
| Imports for consumption | 279 | 316 | 260 | 230 | 270 |
| Exports | 16 | 20 | 19 | 21 | 24 |
| Consumption, apparent | 524 | 602 | 485 | 506 | 570 |
| Stocks, producer, yearend | NA | NA | NA | NA | NA |
| Employment, plant, number[e] | 300 | 300 | 275 | 250 | 250 |
| Net import reliance[2] as a percentage of apparent consumption | 50 | 49 | 50 | 41 | 43 |

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

**Import Sources (2010–13):** China, 54%; Brazil, 11%; Australia, 8%; Canada, 8%; and other, 19%.

| Tariff:[3] Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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:** Historically, the majority of magnesium compounds consumed in the United States was for refractory products. Since 2013, however, refractories have accounted for less than 50% of magnesium compounds consumed. Although steel production in the United States increased slightly in 2014, the use of higher quality fused-magnesia refractories resulted in decreased refractory consumption per unit of steel produced. Increased consumption of magnesium compounds for animal feed supplements, deicing, dust control, fertilizer, flue gas treatment, and waste water treatment also contributes to the shift in end use distribution.

Global consumption of all refractories was 10% lower in 2013 than that in 2011. Magnesia brick consumption in China in 2013 was 16% lower than that in 2012. The decrease in consumption was partially attributed to slower economic growth in China and the Government of China ordering older, inefficient capacity in the steel, cement, and glass industries to be shut down. In addition, production of higher quality refractories that last longer also decreased consumption of magnesia. Dead-burned magnesia was being replaced with fused magnesia in some steel furnaces. Fused magnesia has superior properties to dead-burned magnesia in some refractory applications, owing to higher magnesia content, higher density, and larger crystal size.

Prepared by **E. Lee Bray [(703) 648–4979, lbray@usgs.gov]**

# MAGNESIUM COMPOUNDS

Although the trends of more efficient use of refractory products and slower growth in China were expected to continue, concerns about the availability of raw materials have lead several refractory producers to secure captive sources of magnesia in recent years. Further consumer acquisitions of raw-material suppliers were expected. New or reopened production capacity has provided consumers with an alternative to fused magnesia produced in China. A magnesite mine in Greece that had been shut down for about 15 years was reopened in late 2013 and began shipping magnesite in 2014. The plant had a capacity to produce 15,000 metric tons per year of caustic calcined magnesia and was building a 60,000-ton-per-year kiln. In Russia, the leading magnesia producer commissioned a new fused magnesia furnace with a capacity of 50,000 tons per year.

**World Magnesite Mine Production and Reserves:**

| | Mine production | | Reserves[4] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | W | W | 10,000 |
| Australia | 130 | 130 | 95,000 |
| Austria | 220 | 200 | 15,000 |
| Brazil | 140 | 150 | 86,000 |
| China | 4,900 | 4,900 | 500,000 |
| Greece | 100 | 115 | 80,000 |
| India | 60 | 60 | 20,000 |
| Korea, North | 70 | 80 | 450,000 |
| Russia | 370 | 400 | 650,000 |
| Slovakia | 200 | 200 | 35,000 |
| Spain | 280 | 280 | 10,000 |
| Turkey | 300 | 300 | 49,000 |
| Other countries | 130 | 150 | 390,000 |
| World total (rounded) | [5]6,910 | [5]6,970 | 2,400,000 |

In addition to magnesite, there are vast reserves of well and lake brines and seawater from which magnesium compounds can be recovered.

**World Resources:** Resources from which magnesium compounds can be recovered range from large to virtually unlimited and are globally widespread. Identified world resources of magnesite total 12 billion tons, and of brucite, several million tons. Resources of dolomite, forsterite, magnesium-bearing evaporite minerals, and magnesia-bearing brines are estimated to constitute a resource in billions of tons. Magnesium hydroxide can be recovered from seawater.

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

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data.
[1]See also Magnesium Metal.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]Tariffs are based on gross weight.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.
[5]Excludes U.S. production.

# MAGNESIUM METAL[1]

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** In 2014, primary magnesium was produced by one company in Utah at an electrolytic process plant that recovered magnesium from brines from the Great Salt Lake. The leading use for primary magnesium metal was aluminum-base alloys that were used for packaging, transportation, and other applications, which accounted for 35% of apparent consumption. Use as a reducing agent for the production of titanium and other metals accounted for 30% of primary magnesium consumption. Structural uses of magnesium (castings and wrought products) accounted for 15% of primary metal consumption, desulfurization of iron and steel, 10%, and other uses, 10%.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production: | | | | | |
| Primary | W | W | W | W | W |
| Secondary (new and old scrap) | 72 | 67 | 77 | 79 | 82 |
| Imports for consumption | 53 | 48 | 51 | 46 | 55 |
| Exports | 15 | 12 | 18 | 16 | 18 |
| Consumption: | | | | | |
| Reported, primary | 57 | 81 | 72 | 69 | 80 |
| Apparent[2] | 100 | 110 | 110 | 120 | 120 |
| Price, yearend: | | | | | |
| U.S. spot Western, dollars per pound, average | 2.43 | 2.13 | 2.20 | 2.13 | 2.15 |
| China free market, dollars per metric ton, average | 2,925 | 3,025 | 3,170 | 2,590 | 2,500 |
| Stocks, producer and consumer, yearend | W | W | W | W | W |
| Employment, number[e] | 400 | 400 | 420 | 420 | 420 |
| Net import reliance[3] as a percentage of apparent consumption | 38 | 33 | 29 | 27 | 30 |

**Recycling:** In 2014, about 25,000 tons of secondary magnesium was recovered from old scrap and 57,000 tons were recovered from new scrap. Aluminum-base alloys accounted for 75% of the secondary magnesium recovered. Magnesium chloride produced as a waste product of titanium sponge production at a plant in Utah is returned to the primary magnesium supplier where it is reduced to produce metallic magnesium; however, this metal is not included in the secondary magnesium statistics.

**Import Sources (2010–13):** Israel, 33%; Canada, 23%; China, 8%; United Kingdom, 7%; and others, 29%.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Unwrought metal | 8104.11.0000 | 8.0% ad val. |
| Unwrought alloys | 8104.19.0000 | 6.5% 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:** Several projects under development could significantly increase primary magnesium metal capacity in North America. In February 2014, the sole U.S. primary magnesium producer announced plans to expand capacity to 76,500 tons per year from 63,500 tons per year by yearend 2015. Engineering studies were completed for a proposal to expand the plant capacity to 90,000 tons per year, although a proposed construction schedule for that expansion was not released. Net import reliance as a percentage of apparent magnesium consumption has gone down to 30% in 2014 from 61% in 2004, even though apparent consumption has gone down by about 15% during the same time owing to recent expansions by this producer. The company and the union which represents its workers signed a 5-year labor contract that took effect at the end of August. In Nevada, a company was proposing to build a plant to produce magnesium from dolomite. A preliminary economic assessment of the dolomite deposit was completed in 2012, but permits have not been issued for the project. In Quebec, Canada, a company was building a pilot plant to test production of magnesium from tailings from asbestos mining. If the pilot plant proves the company's process to be economically feasible, the company planned to build a 50,000-ton-per-year plant.

Prepared by **E. Lee Bray, [(703) 648–4979, lbray@usgs.gov]**

# MAGNESIUM METAL

The use of magnesium in automobile parts was expected to continue to increase as automobile manufactures seek to decrease vehicle weight to comply with fuel efficiency standards. In September, an expansion project started at a plant in Mexico, MO, which manufactures die-cast magnesium parts for the automotive industry. The capacity of the plant and the expansion project were not released, but employment at the plant was expected to increase by about 30% when completed in September 2015. Consumption of magnesium in the production of titanium metal by the Kroll process was expected to increase as the use of titanium increases in aerospace applications.

In China, expansion of capacity to produce magnesium metal continued in areas adjacent to sources of dolomite or lake brines and coking operations. Although much of the newer capacity is in locations with lower costs, such as Shaanxi Province, older capacity was still producing at reduced rates and could increase output if prices supported it. A company in Norway was building a 15,000-ton-per-year plant to produce magnesium from olivine. The plant was expected to be completed at mid-year 2015. It would also include secondary magnesium capacity.

The U.S. Department of Energy's (DOE) Advanced Research Projects Agency-Energy was funding a project to develop a method of recovering magnesium from seawater using less energy than current production methods. The 3-year project conducted at DOE's Pacific Northwest National Laboratory in Richland, WA, was started in January 2014, and funded for $2.7 million. Two corporate partners were also participating in the research project.

**World Primary Production and Reserves:**

| | Primary production | |
|---|---|---|
| | 2013 | 2014[e] |
| United States | W | W |
| Brazil | 16 | 16 |
| China | 770 | 800 |
| Israel | 28 | 30 |
| Kazakhstan | 23 | 21 |
| Korea, Republic of | 8 | 10 |
| Malaysia | 1 | 0 |
| Russia | 32 | 28 |
| World total[5] (rounded) | 878 | 907 |

**Reserves[4]**

Magnesium metal is derived from seawater, natural brines, dolomite, and other minerals. The reserves for this metal are sufficient to supply current and future requirements. To a limited degree, natural brines may be considered to be a renewable resource wherein any magnesium removed by humans may be renewed by nature in a short span of time.

**World Resources:** Resources from which magnesium may be recovered range from large to virtually unlimited and are globally widespread. Resources of dolomite 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. For iron and steel desulfurization, calcium carbide may be used instead of magnesium. Magnesium's light weight is an advantage over aluminum and zinc in castings and wrought products; however, its high cost is a disadvantage relative to these substitutes. 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.
[1]See also Magnesium Compounds.
[2]Rounded to two significant digits to protect proprietary data.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.
[5]Excludes U.S. production.

# MANGANESE

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

**Domestic Production and Use:** Manganese ore containing 20% or more manganese has not been produced domestically since 1970. Manganese ore was consumed mainly by 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 plant fertilizers and animal feed, and as a brick colorant. Manganese ferroalloys were produced at two smelters. Construction, machinery, and transportation end uses accounted for about 33%, 13%, and 10%, respectively, of manganese consumption. Most of the rest went to a variety of other iron and steel applications. In 2014, the value of domestic consumption, estimated from foreign trade data, was about $1.2 billion.

| Salient Statistics—United States:[1] | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, mine[2] | — | — | — | — | — |
| Imports for consumption: | | | | | |
| Manganese ore | 489 | 552 | 506 | 549 | 430 |
| Ferromanganese | 326 | 348 | 401 | 331 | 360 |
| Silicomanganese[3] | 297 | 348 | 348 | 329 | 450 |
| Exports: | | | | | |
| Manganese ore | 14 | 1 | 2 | 1 | 1 |
| Ferromanganese | 19 | 5 | 5 | 2 | 7 |
| Silicomanganese | 9 | 8 | 6 | 6 | 2 |
| Shipments from Government stockpile excesses:[4] | | | | | |
| Manganese ore | — | -75 | — | — | — |
| Ferromanganese | 29 | 10 | 6 | 1 | 20 |
| Consumption, reported:[5] | | | | | |
| Manganese ore[6] | 450 | 532 | 538 | 523 | 500 |
| Ferromanganese | 292 | 303 | 382 | 368 | 370 |
| Silicomanganese | 97 | 106 | 150 | 152 | 150 |
| Consumption, apparent, manganese[7] | 721 | 699 | 843 | 794 | 840 |
| 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] | 8.45 | 6.67 | 4.97 | 4.61 | 4.30 |
| CNF[8] China, CRU Ryan's Notes | 7.23 | 5.72 | 4.84 | 5.29 | [9]5.01 |
| Stocks, producer and consumer, yearend: | | | | | |
| Manganese ore[6] | 168 | 250 | 203 | 217 | 200 |
| Ferromanganese | 32 | 25 | 31 | 27 | 27 |
| Silicomanganese | 28 | 22 | 19 | 6 | 15 |
| Net import reliance[10] 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 (2010–13):** Manganese ore: Gabon, 61%; Australia, 16%; South Africa, 14%; Ghana, 4%; and other, 5%. Ferromanganese: South Africa, 57%; Norway, 9%; Ukraine, 8%; Republic of Korea, 7%; and other, 19%. Manganese contained in principal manganese imports:[11] South Africa, 32%; Gabon, 22%; Australia, 12%; Georgia, 8%; and other, 26%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Ore and concentrate | 2602.00.0040/60 | Free. |
| Manganese dioxide | 2820.10.0000 | 4.7% ad val. |
| High-carbon ferromanganese | 7202.11.5000 | 1.5% ad val. |
| Silicomanganese | 7202.30.0000 | 3.9% ad val. |
| Metal, unwrought | 8111.00.4700/4900 | 14% ad val. |

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

Prepared by **Lisa A. Corathers [(703) 648–4973, lcorathers@usgs.gov]**

# MANGANESE

**Government Stockpile:**

**Stockpile Status—9–30–14**[12]

| Material | Inventory | Disposal Plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|
| Manganese ore[13] | 292 | 91 | — |
| Ferromanganese, high-carbon[e] | 329 | 91 | 17 |

**Events, Trends, and Issues:** U.S. manganese apparent consumption was projected to increase by 5% to 840,000 metric tons in 2014 compared to that in 2013. This happened despite a significant (22%) decrease in domestic manganese ore consumption during 2014 that resulted from a 6-month curtailment in production at one U.S. silicomanganese plant. Greater ferromanganese and silicomanganese imports and excess high-carbon ferromanganese shipments from the Government stockpile in 2014 led to the increased U.S. apparent consumption. The annual average domestic manganese ore contract price followed the 7% decrease in the average Chinese spot market price for metallurgical-grade ore in 2014.

**World Mine Production and Reserves (metal content):** Reserves for India have been revised based on the average metal content of manganese ore produced from 2009–13.

| | Mine production | | Reserves[14] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | — | — |
| Australia | 2,980 | 3,100 | 97,000 |
| Brazil | 1,120 | 1,100 | 54,000 |
| Burma | 157 | 200 | NA |
| China | 3,000 | 3,200 | 44,000 |
| Gabon | 1,970 | 2,000 | 24,000 |
| Ghana | 533 | 540 | NA |
| India | 920 | 940 | 52,000 |
| Kazakhstan | 390 | 390 | 5,000 |
| Malaysia | 430 | 440 | NA |
| Mexico | 212 | 220 | 5,000 |
| South Africa | 4,300 | 4,700 | 150,000 |
| Ukraine | 300 | 300 | 140,000 |
| Other countries | 597 | 650 | Small |
| World total (rounded) | 16,900 | 18,000 | 570,000 |

**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 75% of the world's identified manganese resources, and Ukraine accounts for 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]Excludes insignificant quantities of low-grade manganiferous ore.
[3]Imports more nearly represent amount consumed than does reported consumption.
[4]Net quantity, in manganese content, defined as stockpile shipments – receipts.
[5]Manganese consumption cannot be estimated as the sum of manganese ore and ferromanganese consumption because so doing would count manganese in ore used to produce ferromanganese twice.
[6]Consumers only, exclusive of ore consumed at iron and steel plants.
[7]Thousand metric tons, manganese content; based on estimated average content for all components except imports, for which content is reported.
[8]Cost and freight (CNF) represents the costs paid by a seller to ship manganese ore by sea to a Chinese port; excludes insurance.
[9]Average weekly price through September 2014.
[10]Defined as imports – exports + adjustments for Government and industry stock changes.
[11]Includes imports of ferromanganese, manganese ore, silicomanganese, synthetic manganese dioxide, and unwrought manganese metal.
[12]See Appendix B for definitions.
[13]Metallurgical grade.
[14]See Appendix C for resource/reserve definitions and information concerning data sources.

# 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 2014, 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 50 metric tons per year of mercury was consumed domestically. The leading domestic end users of mercury were the chlorine-caustic soda, electronics, and fluorescent-lighting industries. With the conversion of one chloralkali mercury cell plant in Tennessee to membrane technology in 2013, and the closure of a mercury cell chloralkali unit in Georgia in 2012, only two mercury cell chloralkali plants operated in the United States in 2014. 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:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine (byproduct) | NA | NA | NA | NA | NA |
| Secondary | NA | NA | NA | NA | NA |
| Imports for consumption (gross weight), metal | 294 | 110 | 249 | 38 | 50 |
| Exports (gross weight), metal | 459 | 133 | 103 | ([1]) | — |
| Price, average value, dollars per flask, free market[2, 3] | 1,076 | 1,850 | 1,850 | 1,850 | 1,850 |
| Net import reliance[4] as a percentage of apparent consumption | E | E | E | NA | NA |

**Recycling:** In 2014, six companies in the United States accounted for the majority of secondary mercury production. Mercury-containing automobile convenience switches, barometers, compact and traditional fluorescent lamps, computers, dental amalgam, medical devices, thermostats, and some mercury-containing toys were collected by as many as 50 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. The increased use of nonmercury substitutes has resulted in a shrinking reservoir of mercury-containing products for recycling.

**Import Sources (2010–13):** Chile, 45%; Peru, 22%; Argentina, 15%; Canada, 10%; and other, 8%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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, Hawthorne, NV. About 1,200 tons of mercury also was held by the U.S. Department of Energy, Oak Ridge, TN. Sales of mercury from the National Defense Stockpile remained suspended.

**Stockpile Status—9–30–14[5]**

| Material | Inventory | Disposal Plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|
| Mercury | 4,440 | — | — |

**Events, Trends, and Issues:** The average monthly price of one flask of domestic mercury and free market mercury was unchanged at $1,850 per flask throughout the year. Imports increased but were still significantly below the average imports for the last 10 years.

Owing to mercury toxicity and concerns for the environment and human health, overall mercury use has declined in the United States. Mercury has been released to the environment from numerous sources, including mercury-containing car switches when automobiles are scrapped for recycling, coal-fired powerplant emissions, and incinerated mercury-containing medical devices. Mercury is no longer used in batteries and paints manufactured in

Prepared by **Micheal W. George [(703) 648–4962, mgeorge@usgs.gov]**

# MERCURY

the United States. Some button-type batteries, cleansers, fireworks, folk medicines, grandfather clocks, pesticides, and some skin-lightening creams and soaps may contain mercury. Global consumption of mercury was estimated to be less than 2,000 tons per year, and approximately 50% of this consumption was as mercury compounds used as catalysts in the coal-based manufacture of vinyl chloride monomer in China. Conversion to nonmercury technology for chloralkali production and the ultimate closure of the world's mercury-cell chloralkali plants may release a large quantity of mercury to the global market for recycling, sale, or, owing to export bans in Europe and the United States, storage.

Globally, the number of operating primary mercury mines was uncertain; however, the majority was located in China, Kyrgyzstan, or Russia. 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 until sufficient material is available for export. Domestic mercury consumption will continue to decline as increasing usage of compact fluorescent and fluorescent light bulbs, which use a small amount of mercury, will be offset by increasing use of nonmercury-containing products, such as digital thermometers, are substituted for mercury-containing products.

**World Mine Production and Reserves:** Data on reserves of mercury are out of date, not available, or not disclosed due to the hazardous nature of the mineral.

| | Mine production | | Reserves[6] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | NA | NA | Quantitative estimates of reserves are not available. China, Kyrgyzstan, and Peru are thought to contain the largest reserves. |
| Chile (byproduct) | 50 | 50 | |
| China | 1,600 | 1,600 | |
| Kyrgyzstan | 100 | 100 | |
| Mexico (byproduct) | NA | NA | |
| Peru (exports) | 45 | 40 | |
| Russia | 50 | 50 | |
| Tajikistan | 32 | 30 | |
| World Total (rounded) | 1,880 | 1,870 | |

**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 Peru, mercury production from the Santa Barbara Mine (Huancavelica) stopped in the 1990s; however, Peru continues to be an important source of byproduct mercury imported into the United States. Spain, once a leading producer of mercury from its centuries-old Almaden Mine, stopped mining 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 another century or more of use.

**Substitutes:** For aesthetic or human health concerns, natural-appearing 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. Light-emitting diodes 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]Platts Metals Week average mercury price quotation for the year. Actual prices may vary significantly from quoted prices.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix B for definitions.
[6]See Appendix C for resource/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 49,500 tons valued at $6.0 million. Mica was mined in Georgia, North Carolina, South Dakota, and Virginia. Scrap mica was recovered principally from mica and sericite schist and as a byproduct from feldspar, kaolin, and industrial sand beneficiation. Seven companies produced 80,000 t of ground mica from domestic and imported scrap and flake mica valued at $24 million. 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 upon imports to meet demand for sheet mica. Most sheet mica was fabricated into parts for electronic and electrical equipment.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Scrap and flake: | | | | | |
| Production:[1, 2] | | | | | |
| Mine | 56,100 | 52,000 | 47,500 | 48,100 | 49,500 |
| Ground | 75,600 | 80,400 | 78,500 | 79,200 | 80,000 |
| Imports, mica powder and mica waste | 26,400 | 27,500 | 27,200 | 30,900 | 29,800 |
| Exports, mica powder and mica waste | 6,480 | 5,870 | 5,890 | 6,260 | 7,950 |
| Consumption, apparent[3] | 76,000 | 73,600 | 68,800 | 72,700 | 71,400 |
| Price, average, dollars per metric ton, reported: | | | | | |
| Scrap and flake | 147 | 133 | 128 | 124 | 120 |
| Ground: | | | | | |
| Dry | 285 | 281 | 281 | 279 | 279 |
| Wet | 360 | 360 | 360 | 360 | 360 |
| Employment, mine, number | NA | NA | NA | NA | NA |
| Net import reliance[4] as a percentage of apparent consumption | 26 | 29 | 31 | 34 | 31 |
| Sheet: | | | | | |
| Production, mine[e] | ([5]) | ([5]) | ([5]) | ([5]) | ([5]) |
| Imports, plates, sheets, strips; worked mica; split block; splittings; other >$1.00/kg | 1,980 | 2,190 | 2,380 | 1,910 | 2,290 |
| Exports, plates, sheets, strips; worked mica; crude and rifted into sheet or splittings >$1.00/kg | 932 | 1,040 | 1,660 | 1,270 | 1,570 |
| Shipments from Government stockpile excesses | — | — | — | — | — |
| Consumption, apparent | 1,050 | 1,160 | 716 | 640 | 717 |
| Price, average value, dollars per kilogram, muscovite and phlogopite mica, reported: | | | | | |
| Block | 130 | 152 | 176 | 175 | 175 |
| Splittings | 1.53 | 1.63 | 1.72 | 1.72 | 1.72 |
| Stocks, fabricator and trader, yearend | NA | NA | NA | NA | NA |
| Net import reliance[4] as a percentage of apparent consumption | 100 | 100 | 100 | 100 | 100 |

**Recycling:** None.

**Import Sources (2010–13):** Scrap and flake: Canada, 42%; China, 27%; Finland, 8%; Mexico, 7%; and other, 16%. Sheet: India, 94%; China, 5%; and other, 1%.

| **Tariff:** **Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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. |

Prepared by **Jason Christopher Willett [(703) 648-6473, jwillett@usgs.gov]**

# MICA (NATURAL)

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

**Government Stockpile:** None.

**Events, Trends, and Issues:** Domestic production and consumption of scrap and flake mica were estimated to have increased in 2014. Apparent consumption of scrap and flake mica decreased slightly in 2014 because of an estimated 27% increase in exports. Apparent consumption of sheet mica increased in 2014. No environmental concerns are associated with the manufacture and use of mica products.

Significant stocks of sheet mica previously sold from the National Defense Stockpile (NDS) to domestic and foreign mica traders, brokers, and processors were exported, possibly resulting in understating apparent consumption in 2006 through 2009. The NDS has not held mica since 2008, when the last stocks of muscovite block were sold. Future supplies for U.S. consumption were expected to come increasingly from imports, primarily from Brazil, China, India, and Russia.

**World Mine Production and Reserves:**

| | Scrap and flake | | | Sheet | | |
|---|---|---|---|---|---|---|
| | Mine production[e] | | Reserves[6] | Mine production[e] | | Reserves[6] |
| | 2013 | 2014 | | 2013 | 2014 | |
| All types: | | | | | | |
| United States[1] | 48,100 | 49,500 | Large | ([5]) | ([5]) | Very small |
| Argentina | 10,000 | 10,000 | Large | — | — | NA |
| Canada | 22,000 | 16,000 | Large | — | — | NA |
| China | 780,000 | 800,000 | Large | — | — | NA |
| Finland | 53,400 | 53,400 | Large | | | NA |
| France | 20,000 | 20,000 | Large | — | — | NA |
| India | 14,300 | 14,700 | Large | 2,000 | 1,260 | Very large |
| Korea, Republic of | 30,000 | 30,000 | Large | — | — | NA |
| Russia | 100,000 | 100,000 | Large | 1,500 | 1,500 | Moderate |
| Other countries | 42,500 | 36,800 | Large | 200 | 200 | Moderate |
| World total (rounded) | 1,120,000 | 1,130,000 | Large | 3,700 | 2,960 | 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 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]Based on scrap and flake mica mine production.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]Less than ½ unit.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

# MOLYBDENUM

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

**Domestic Production and Use:** In 2014, molybdenum, valued at about $1.8 billion (based on an average oxide price), was produced at 13 mines. Molybdenum ore was produced as a primary product at three mines—two in Colorado, and one in Idaho—whereas ten copper mines (six in Arizona, one each in Montana, Nevada, New Mexico, 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. Iron and steel and superalloy producers accounted for about 74% of the molybdenum consumed.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, mine | 59,400 | 63,700 | 61,500 | 60,700 | 65,500 |
| Imports for consumption | 19,700 | 21,100 | 19,800 | 20,200 | 23,600 |
| Exports | 49,900 | 56,700 | 48,900 | 53,100 | 55,300 |
| Consumption: | | | | | |
| Reported[1] | 19,200 | 19,100 | 19,400 | 18,600 | 19,000 |
| Apparent[2] | 28,200 | 26,100 | 33,100 | 29,500 | 33,900 |
| Price, average value, dollars per kilogram[3] | 34.83 | 34.34 | 28.09 | 22.85 | 26.90 |
| Stocks, consumer materials | 1,630 | 1,810 | 1,770 | 1,820 | 1,830 |
| Employment, mine and plant, number | 940 | 940 | 940 | 960 | 1,000 |
| 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 is comprised of 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 reutilized. Recycling of molybdenum-bearing scrap will continue to be dependent on the markets for the principal alloy metals of the alloys in which molybdenum is found, such as iron, nickel, and chromium.

**Import Sources (2010–13):** Ferromolybdenum: Chile, 79%; Canada, 9%; United Kingdom, 6%; and other, 6%. Molybdenum ores and concentrates: Canada, 44%; Mexico, 28%; Peru, 22%; Chile, 5%; and other, 1%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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.

Prepared by **Désirée E. Polyak [(703) 648–4909, dpolyak@usgs.gov]**

# MOLYBDENUM

**Events, Trends, and Issues:** U.S. estimated mine output of molybdenum in concentrate in 2014 increased 8% from that of 2013. U.S. imports for consumption increased by 17% from those of 2013, and U.S. exports increased by 4% from those of 2013. Reported U.S. consumption of primary molybdenum products slightly increased from that of 2013. Apparent consumption of roasted molybdenum concentrates increased by 4% from that of 2013.

The average molybdenum price for 2014 was higher than that of 2013. Most byproduct and primary molybdenum mines maintained high production levels in 2014. Primary molybdenum production continued at the Climax Mine in Lake County and Summit 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, was expected to be put on care and maintenance at yearend 2014. Both the Mission Mine in Pima County, AZ, and the Pinto Valley Mine in Gila County, AZ, restarted their molybdenum circuits in 2014.

In November, China cancelled export quotas (25,000 t) for molybdenum for 2015. This comes after a World Trade Organization panel concluded in March that China violated the organization's membership obligation by restricting exports of molybdenum.

**World Mine Production and Reserves:** Reserves for Australia were updated with data from Geoscience Australia.

| | Mine production | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014[e] | (thousand metric tons) |
| United States | 60,700 | 65,500 | 2,700 |
| Armenia | 6,700 | 6,700 | 150 |
| Australia | — | — | 200 |
| Canada | 7,620 | 9,500 | 260 |
| Chile | 38,700 | 39,000 | 1,800 |
| China | 101,000 | 100,000 | 4,300 |
| Iran | 4,000 | 6,300 | 50 |
| Kazakhstan | — | — | 130 |
| Kyrgyzstan | NA | NA | 100 |
| Mexico | 12,100 | 11,000 | 130 |
| Mongolia | 1,900 | 2,000 | 160 |
| Peru | 18,100 | 18,100 | 450 |
| Russia[e] | 4,800 | 4,800 | 250 |
| Turkey | 1,500 | 2,800 | 100 |
| Uzbekistan[e] | 530 | 550 | 60 |
| World total (rounded) | 258,000 | 266,000 | 11,000 |

**World Resources:** Identified resources of molybdenum in the United States are about 5.4 million tons, and in the rest of the world, about 14 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 as an alloying element 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 the alloying properties of the metal. Potential substitutes for molybdenum include boron, chromium, niobium (columbium), and vanadium in alloy steels; tungsten in tool steels; graphite, tantalum, and tungsten for refractory materials in high-temperature electric furnaces; and cadmium-red, chrome-orange, and organic-orange pigments for molybdenum orange.

[e]Estimated. E Net exporter. NA Not available. — Zero.
[1]Reported consumption of primary molybdenum products.
[2]Apparent consumption of molybdenum concentrates roasted to make molybdenum oxide.
[3]Time-weighted average price per kilogram of molybdenum contained in technical-grade molybdic oxide, as reported by Ryan's Notes.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.

# NICKEL

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

**Domestic Production and Use:** The United States had only one active nickel mine—the underground Eagle Mine in Michigan. The new chalcopyrite-pentlandite mine was commissioned in April 2014, returning the United States to the family of nickel producing countries after an absence of 18 years. Three mining projects were in varying stages of development in northeastern Minnesota. The principal nickel-consuming State was Pennsylvania, followed by Kentucky, Illinois, New York, and North Carolina. Approximately 45% of the primary nickel consumed went into stainless and alloy steel production, 43% into nonferrous alloys and superalloys, 7% into electroplating, and 5% into other uses. End uses were as follows: transportation and defense, 34%; fabricated metal products, 20%; electrical equipment, 13%; chemical and petroleum industries, 7% each; construction, household appliances, and industrial machinery, 5% each; and other, 4%. The estimated value of apparent primary consumption was $2.50 billion.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine | — | — | — | — | 3,600 |
| Refinery, byproduct | W | W | W | W | W |
| Shipments of purchased scrap[1] | 139,000 | 132,000 | 130,000 | 124,000 | 119,000 |
| Imports: | | | | | |
| Primary | 129,000 | 138,000 | 133,000 | 126,000 | 158,000 |
| Secondary | 23,800 | 21,300 | 22,300 | 26,300 | 39,500 |
| Exports: | | | | | |
| Primary | 12,600 | 12,400 | 9,100 | 10,600 | 10,300 |
| Secondary | 80,300 | 64,800 | 59,800 | 61,200 | 57,500 |
| Consumption: | | | | | |
| Reported, primary | 100,000 | 110,000 | 114,000 | 114,000 | 148,000 |
| Reported, secondary | 81,900 | 88,800 | 92,400 | 88,800 | 102,000 |
| Apparent, primary | 114,000 | 125,000 | 125,000 | 110,000 | 148,000 |
| Total[2] | 196,000 | 213,000 | 218,000 | 199,000 | 250,000 |
| Price, average annual, London Metal Exchange: | | | | | |
| Cash, dollars per metric ton | 21,804 | 22,890 | 17,533 | 15,018 | 16,863 |
| Cash, dollars per pound | 9.890 | 10.383 | 7.953 | 6.812 | 7.649 |
| Stocks: | | | | | |
| Consumer, yearend | 16,800 | 18,100 | 16,600 | 18,500 | 20,900 |
| Producer, yearend[3] | 6,240 | 6,610 | 6,380 | 9,730 | 7,640 |
| Net import reliance[4] as a percentage of apparent consumption | 41 | 48 | 49 | 46 | 54 |

**Recycling:** About 102,000tons of nickel was recovered from purchased scrap in 2014. This represented about 41% of reported secondary plus apparent primary consumption for the year.

**Import Sources (2010–13):** Canada, 36%; Russia, 14%; Australia, 11%; Norway, 10%; and other, 29%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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).

**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 are expected to generate an additional 20,000 tons of nickel in scrap.

**Events, Trends, and Issues:** The U.S. steel industry produced 1.64million tons of austenitic (nickel-bearing) stainless steel in 2014—up 8% from 2013,and 39% greater than the reduced output of 1.18million tons in 2009. 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. China, the world's leading steel producer, cast a record-high 16.7million tons of austenitic stainless steel in 2014.

Prepared by **Peter H. Kuck [(703) 648–4965, pkuck@usgs.gov]**

# NICKEL

Nickel prices increased by 12% in 2014 despite weak economic conditions in some developing countries and parts of the European Union. In May 2014, the London Metal Exchange (LME) cash mean for 99.8%-pure nickel peaked briefly at $19,434 per metric ton after partially recovering from a downturn in mid-2013. However, the cash price started contracting again in the fourth quarter of 2014 as manufacturing cutbacks in the euro area, related economic problems, and the threat of deflation helped to depress prices. By October, the cash price had fallen to $15,765 per metric ton and was accompanied by the gradual buildup of stocks in LME warehouses to record high levels. At the end of October, LME warehouses held more than 385,000 tons of nickel metal.

Despite current weak prices and an oversupply of the metal, mining companies continue to bring on new nickel projects in anticipation of a turnaround in the global economy. Global production of austenitic stainless steel continues to increase and was at an all-time high in 2014, with China accounting for more than one-half of the year's output. Demand for nickel-base superalloys is also increasing and has been especially strong in the aerospace and power-generation sectors. In January 2014, the Government of Indonesia banned the export of direct shipping ores of nickel, hoping to encourage the construction of additional ferronickel and nickel pig iron production facilities in the archipelago. In May, the world's leading producer of nickel announced that it would focus on its core operations in Russia and began selling off assets in Australia, Botswana, and South Africa.

**World Mine Production and Reserves:** Reserves data for Australia, Brazil, Canada, the Dominican Republic, Indonesia, the Philippines, and Russia were revised based on new information from company or Government reports.

| | Mine production | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | 3,600 | 160,000 |
| Australia | 234,000 | 220,000 | [6]19,000,000 |
| Brazil | 138,000 | 126,000 | 9,100,000 |
| Canada | 223,000 | 233,000 | 2,900,000 |
| China | 95,000 | 100,000 | 3,000,000 |
| Colombia | 75,000 | 75,000 | 1,100,000 |
| Cuba | 66,000 | 66,000 | 5,500,000 |
| Dominican Republic | 15,800 | — | 930,000 |
| Indonesia | 440,000 | 240,000 | 4,500,000 |
| Madagascar | 29,200 | 37,800 | 1,600,000 |
| New Caledonia[7] | 164,000 | 165,000 | 12,000,000 |
| Philippines | 446,000 | 440,000 | 3,100,000 |
| Russia | 275,000 | 260,000 | 7,900,000 |
| South Africa | 51,200 | 54,700 | 3,700,000 |
| Other countries | 377,000 | 410,000 | 6,500,000 |
| World total (rounded) | 2,630,000 | 2,400,000 | 81,000,000 |

**World Resources:** Identified land-based resources averaging 1% nickel or greater contain at least 130 million tons of nickel. About 60% is in laterites and 40% is in sulfide deposits. Extensive resources of nickel are also found in manganese crusts and nodules covering large areas of the ocean floor. The long-term decline in discovery of new sulfide deposits in traditional mining districts has forced exploration teams to shift to more challenging locations like east-central Africa and the Subarctic. Development of awaruite deposits in Canada may help alleviate projected shortages of nickel concentrate. Awaruite, a natural iron-nickel alloy, is easier to concentrate than pentlandite.

**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-based alloys in corrosive chemical environments. Lithium-ion batteries instead of nickel-metal hydride may be used 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]Apparent primary consumption + reported secondary consumption.
[3]Stocks of producers, agents, and dealers held only in the United States.
[4]Defined as imports – exports + adjustments for industry stock changes.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]For Australia, Joint Ore Reserves Committee (JORC)-compliant reserves were about 8.3 million tons.
[7]Overseas territory of France.

# 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. Forty-three 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, 79%; and superalloys, 21%. In 2014, the estimated value of niobium consumption was $500 million, as measured by the value of imports.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine | — | — | — | — | — |
| Recycling | NA | NA | NA | NA | NA |
| Imports for consumption[e, 1] | 8,490 | 9,520 | 10,100 | 8,580 | 11,000 |
| Exports[e, 1] | 281 | 363 | 385 | 435 | 1,000 |
| Government stockpile releases[e, 2] | — | — | — | — | — |
| Consumption:[e] | | | | | |
| Apparent | 8,210 | 9,160 | 9,730 | 8,140 | 10,000 |
| Reported[3] | 5,590 | 9,060 | 7,460 | 7,500 | 8,000 |
| Unit value, ferroniobium, dollars per metric ton[4] | 37,781 | 41,825 | 43,658 | 43,415 | 42,000 |
| Net import reliance[5] 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 (2010–13):** Niobium ore and concentrate: Brazil, 30%; Canada, 18%; Australia, 11%; Rwanda, 8%; and other, 33%. Niobium metal and oxide: Brazil, 84%; Canada, 11%; and other, 5%. Total imports: Brazil, 84%; Canada, 11%; and other, 5%. Of the U.S. niobium material imports, 95% (by gross mass) was niobium metal and oxide.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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% of P or S, or less than 0.4% of Si | 7202.93.4000 | 5.0% ad val. |
| Other | 7202.93.8000 | 5.0% ad val. |
| Niobium, unwrought: | | |
| Waste and scrap[6] | 8112.92.0600 | Free. |
| Alloys, metal, powders | 8112.92.4000 | 4.9% ad val. |
| Niobium, other[6] | 8112.99.9000 | 4.0% ad val. |

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

**Government Stockpile:** In the annual materials plan for FY 2015, the Defense Logistics Agency Strategic Materials announced a 2015–18 maximum acquisition limit of 104.5 t for ferroniobium.

Prepared by **John F. Papp [(703) 648–4963, jpapp@usgs.gov]**

# NIOBIUM (COLUMBIUM)

**Stockpile Status—9–30–14**[7]

| Material | Inventory | Disposal Plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|
| Niobium metal | 10.0 | — | — |

**Events, Trends, and Issues:** Niobium principally was imported in the form of ferroniobium and niobium unwrought metal, alloy, and powder. U.S. niobium import dependence was expected to be the same in 2014 as in 2013, when Brazil was the leading niobium supplier. Based on data for part of 2014, U.S. niobium apparent consumption (measured in contained niobium) was estimated at 10,000 metric tons, 23% more than that of 2013. The unit value of U.S. imported ferroniobium between 1990 and 2005 declined from about $20,000 per ton to about $13,000 per ton. It then rose steadily to about $44,000 per ton in 2012, and then declined to $40,000 per ton in 2014, interrupted only in 2008–09 as a result of the global economic downturn. During the initial part of the value increase (2006–08), CBMM, the leading world ferroniobium producer, doubled its niobium production capacity. The value increase that started in 2006 appears to have been a market adjustment to structural undervaluing of ferroniobium. The price of ferroniobium appears to be demand inelastic as demonstrated by the minimal effect of global economic downturn on price in 2009.

Brazil is the world's leading niobium producer with 90% of production followed by Canada with 9%. Niobec mine, the sole niobium producer in Canada, was sold to a group of companies led by Magris Resources Inc (Hong Kong) [owned 50% by Cheung Kong (Holdings) Ltd and 50% by the Canadian Imperial Bank of Commerce] and Temasek (Singapore) for about $500 million.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[8] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | — | — |
| Brazil | 53,100 | 53,000 | 4,100,000 |
| Canada | 5,260 | 5,000 | 200,000 |
| Other countries | 1,000 | 1,000 | NA |
| World total (rounded) | 59,400 | 59,000 | >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-identified resources, all of which were considered uneconomic at 2013 prices for niobium.

**Substitutes:** The following materials can be substituted for niobium, but a performance or cost penalty 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]Includes ferroniobium and nickel niobium.
[4]Unit value is mass-weighted average U.S. import value of ferroniobium assuming 65% niobium content. To convert dollars per metric ton to dollars per pound, divide by 2,205.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.
[6]This category includes other than niobium-containing material.
[7]See Appendix B for definitions.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.

# NITROGEN (FIXED)—AMMONIA

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

**Domestic Production and Use:** Ammonia was produced by 13 companies at 29 plants in 15 States in the United States during 2014; 2 additional plants were idle for the entire year. About 60% of total U.S. ammonia production capacity was centered in Louisiana, Oklahoma, and Texas because of their large reserves of natural gas, the dominant domestic feedstock. In 2014, U.S. producers operated at about 80% of rated capacity. The United States was one of the world's leading producers and consumers of ammonia. Urea, ammonium nitrate, ammonium phosphates, nitric acid, and ammonium sulfate were the major derivatives of ammonia in the United States, in descending order of importance.

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 plastics, synthetic fibers and resins, explosives, and numerous other chemical compounds.

| **Salient Statistics—United States:**[1] | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production | [2]8,290 | [3]9,350 | [4]8,730 | [4]9,170 | 9,200 |
| Imports for consumption | 5,540 | 5,600 | 5,170 | 4,960 | 5,160 |
| Exports | 36 | 26 | 31 | 196 | 95 |
| Consumption, apparent | 13,800 | 14,900 | 13,900 | 13,900 | 14,300 |
| Stocks, producer, yearend | 165 | 178 | 180 | [4]240 | 190 |
| Price, dollars per ton, average, f.o.b. Gulf Coast[5] | 396 | 531 | 579 | 541 | 530 |
| Employment, plant, number[e] | 1,050 | 1,050 | 1,100 | 1,200 | 1,200 |
| Net import reliance[6] as a percentage of apparent consumption | 40 | 37 | 37 | 34 | 36 |

**Recycling:** None.

**Import Sources (2010–13):** Trinidad and Tobago, 60%; Canada, 17%; Russia, 7%; Ukraine, 7%; and other, 9%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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 $3.60 and $7.00 per million British thermal units for most of the year, with an average of about $4.40 per million British thermal units. Natural gas prices in 2014 were relatively stable; slightly higher prices were a result of increased demand for natural gas owing to unseasonable cold and high temperatures and associated increased demand for power generation. The average Gulf Coast ammonia price gradually increased from $450 per short ton at the beginning of 2014 to around $565 per short ton in September. The average ammonia price for the year was estimated to be about $530 per short ton. The U.S. Department of Energy, Energy Information Administration, projected that Henry Hub natural gas spot prices would average $3.83 per million British thermal units in 2015.

A long period of stable and low natural gas prices in the United States has made it economical for companies to upgrade existing plants and plan for the construction of new nitrogen projects. During the next 4 years, it is expected that about 4.4 million tons of annual production capacity will be added in the United States. The additional capacity will reduce but likely not eliminate nitrogen imports.

Global ammonia capacity is expected to increase by 16% during the next 4 years. Additions in capacity are expected in Asia, Africa, the Middle East, and Latin America. The largest growth is expected in China and Indonesia.

Prepared by **Lori E. Apodaca [(703) 648–7724, lapodaca@usgs.gov]**

# NITROGEN (FIXED)—AMMONIA

According to the U.S. Department of Agriculture, U.S. corn growers planted 38 million hectares of corn in the 2014 crop year (July 1, 2013, through June 30, 2014), which would be 4% less than the area planted in 2013. Corn acreage was expected to increase in a few States in the 2015 crop year because of anticipated higher net returns from corn compared to other commodities. Overall corn acreage in the United States was expected to remain high owing in part to continued U.S. ethanol production and U.S. corn exports in response to a strong global demand for feed grains.

Nitrogen fertilizers were an environmental concern. Overfertilization and the subsequent runoff of excess fertilizer may contribute to nitrogen accumulation in watersheds. Nitrogen in excess fertilizer runoff was suspected to be a cause of the hypoxic zone that arises in the Gulf of Mexico during the summer. A hypoxic zone happens where water near the bottom of an affected area in a large body of water, such as the Gulf of Mexico, contains less than 2 parts per million of dissolved oxygen. This may cause stress or death in bottom-dwelling organisms that cannot move out of the hypoxic zone. Scientists continued to study the effects of fertilization on the Nation’s environmental health.

**World Ammonia Production and Reserves:**

| | Plant production | | Reserves[7] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 9,170 | 9,200 | Available atmospheric nitrogen and sources of natural gas for production of ammonia are considered adequate for all listed countries. |
| Australia | 1,250 | 1,300 | |
| Canada | 3,840 | 3,900 | |
| China | 47,300 | 48,000 | |
| Egypt | 2,660 | 2,600 | |
| France | 2,640 | 2,600 | |
| Germany | 2,820 | 2,800 | |
| India | 12,000 | 12,000 | |
| Indonesia | 5,200 | 5,200 | |
| Iran | 2,500 | 2,500 | |
| Japan | 1,150 | 1,200 | |
| Malaysia | 1,000 | 1,000 | |
| Netherlands | 1,800 | 1,800 | |
| Oman | 1,100 | 1,100 | |
| Pakistan | 2,550 | 2,600 | |
| Poland | 2,100 | 2,100 | |
| Qatar | 2,600 | 3,000 | |
| Russia | 10,300 | 10,300 | |
| Saudi Arabia | 3,700 | 3,700 | |
| Trinidad and Tobago | 4,640 | 4,600 | |
| Ukraine | 4,200 | 4,200 | |
| United Kingdom | 1,100 | 1,100 | |
| Uzbekistan | 1,300 | 1,300 | |
| Venezuela | 1,200 | 1,200 | |
| Other countries | 15,000 | 15,000 | |
| World total (rounded) | 143,000 | 144,000 | |

**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 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]U.S. Department of Commerce (DOC) data unless otherwise noted.
[2]Annual and preliminary data as reported in Current Industrial Reports MQ325B (DOC).
[3]Source: U.S. Census Bureau and The Fertilizer Institute; data adjusted by the U.S. Geological Survey.
[4]Source: The Fertilizer Institute as adjusted by the U.S. Geological Survey.
[5]Source: Green Markets.
[6]Defined as imports – exports + adjustments for Government and industry stock changes.
[7]See Appendix C for resource/reserve definitions and information concerning data sources.

# PEAT

(Data in thousand metric tons unless otherwise noted)[1]

**Domestic Production and Use:** The estimated f.o.b. plant value of marketable peat production in the conterminous United States was $13.0 million in 2014. Peat was harvested and processed by about 31 companies in 12 of the conterminous States. The Alaska Department of Natural Resources, which conducted its own canvass of producers, estimated 93,000 cubic meters of peat was produced in 2013; output was reported only by volume.[2] A production estimate was unavailable for Alaska for 2014. Florida and Minnesota were the leading producing States, in order of quantity harvested. Reed-sedge peat accounted for approximately 88% of the total volume produced followed by sphagnum moss with 10%. About 89% 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:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production | 628 | 568 | 488 | 465 | 510 |
| Commercial sales | 605 | 595 | 484 | 453 | 530 |
| Imports for consumption | 947 | 982 | 909 | 915 | 920 |
| Exports | 69 | 49 | 75 | 41 | 30 |
| Consumption, apparent[3] | 1,560 | 1,470 | 1,240 | 1,380 | 1,400 |
| Price, average value, f.o.b. mine, dollars per ton | 24.39 | 22.73 | 24.44 | 25.37 | 25.00 |
| Stocks, producer, yearend | 100 | 133 | 218 | 174 | 150 |
| Employment, mine and plant, number[e] | 610 | 600 | 580 | 560 | 550 |
| Net import reliance[4] as a percentage of apparent consumption | 60 | 61 | 61 | 66 | 64 |

**Recycling:** None.

**Import Sources (2010–13):** Canada, 97%; and other, 3%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Peat | 2703.00.0000 | Free. |

**Depletion Allowance:** 5% (Domestic).

**Government Stockpile:** None.

Prepared by **Lori E. Apodaca [(703) 648–7724, lapodaca@usgs.gov]**

# PEAT

**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 500,000 tons per year and imported peat from Canada to account for more than 60% of domestic consumption.

The 2014 peat harvest season was shorter across most of Canada's production regions as a result of adverse weather conditions. In Eastern Canada, the largest producing region had a weather-delayed start to the harvest season combined with a wet summer. The Prairie Provinces also had below-average peat harvest. Good weather; however, in midsummer to late summer in Quebec's North Shore was favorable for an above-average 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."

| | Mine production | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 465 | 510 | 150,000 |
| Belarus | 2,970 | 3,000 | 2,600,000 |
| Canada | 1,300 | 1,100 | 720,000 |
| Estonia | 927 | 930 | 60,000 |
| Finland | 7,470 | 7,500 | 6,000,000 |
| Germany | 3,000 | 3,000 | ([6]) |
| Ireland | *6,600 | *4,200 | ([6]) |
| Latvia | 1,380 | 1,380 | 76,000 |
| Lithuania | 386 | 390 | 190,000 |
| Moldova | 475 | 480 | ([6]) |
| Norway | 475 | 480 | ([6]) |
| Poland | 760 | 760 | ([6]) |
| Russia | 1,500 | 1,500 | 1,000,000 |
| Sweden | 3,300 | 3,600 | ([6]) |
| Ukraine | 380 | 380 | ([6]) |
| Other countries | 730 | 700 | 1,400,000 |
| World total (rounded) | *32,100 | *29,900 | 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. peatlands are located in undisturbed areas of Alaska. Total world resources of peat were estimated to be between 5 trillion and 6 trillion tons, covering about 400 million hectares.[7]

**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.

[e]Estimated.
[1]See Appendix A for conversion to short tons.
[2]Harbo, L.A., Mineral Specialist, Alaska Office of Economic Development, oral commun., August 12, 2014.
[3]Defined as production + imports – exports + adjustments for industry stock changes.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]Included with "Other countries."
[7]Lappalainen, Eino, 1996, Global peat resources: Jyvaskyla, Finland, International Peat Society, p. 55.
*Corrections posted February 4, 2015.

# PERLITE

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** In 2014, domestic production of crude perlite was estimated to be 440,000 tons with a value of $24.2 million. Crude ore production was from nine mines operated by seven companies in six Western States. New Mexico continued to be the leading producing State. Processed crude perlite was expanded at 48 plants in 27 States. Domestic consumption was 576,000 tons. The applications were building construction products, 51%; fillers, 15%; horticultural aggregate, 14%; and filter aid, 10%. The remaining 10% included specialty insulations, miscellaneous uses, and estimated expanded perlite consumption.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production[1] | 414 | 420 | 393 | 419 | 440 |
| Imports for consumption[e] | 174 | 193 | 150 | 187 | 183 |
| Exports[e] | 42 | 36 | 38 | 51 | 47 |
| Consumption, apparent | 546 | 577 | 505 | 555 | 576 |
| Price, average value, dollars per ton, f.o.b. mine | 52 | 56 | 52 | 55 | 55 |
| Employment, mine and mill | 102 | 95 | 95 | 117 | 119 |
| Net import reliance[2] as a percentage of apparent consumption | 24 | 27 | 22 | 25 | 24 |

**Recycling:** Not available.

**Import Sources (2010–13):** Greece, 100%.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Vermiculite, perlite and chlorites, unexpanded | 2530.10.0000 | Free. |

**Depletion Allowance:** 10% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **Shawnna M. Bennett [(703) 648–7715, smbennett@usgs.gov]**

# PERLITE

**Events, Trends, and Issues:** Perlite is a siliceous volcanic rock that expands up to 20 times its original volume when quickly heated and provides moisture retention and aeration when added to soil. Construction applications for perlite are vast because it is light weight, fire resistant and an excellent insulator. The amount of processed crude perlite sold or used from U.S. mines increased by 5% in 2014 compared with that reported for 2013. Imports decreased slightly as production met increased demand for perlite-based construction products, fillers, and filter aids over the previous 2 years.

The quantities of processed crude perlite sold or used each year began an upward trend in 2010, and in 2014, nearly reached levels last seen in 2006. With the exception of 2012, crude perlite has seen modest annual increases after the 20% market drop in 2009. Because the bulk of perlite consumption is tied directly to the construction industry, the increase was owing to the increase in building material sales. Green roofing, where perlite is used as the sole growing medium for plants on roofs, has become a more popular trend, and offers a unique sustainable way to insulate a roof while adding foliage to the surface. A previously closed perlite mine reopened in late 2014 as the result of increased demand for crude perlite for construction materials.

According to reported figures the world's leading producers are listed as Greece, Turkey, and the United States with 38%, 21%, and 21% of the world production, respectively. China exported nearly 10% of the world's processed crude perlite; however, complete production data for China and several other countries are unavailable to verify these figures.

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 there is practically no runoff to contribute to water pollution.

**World Processed Perlite Production and Reserves:**

| | Production | | Reserves[3] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 419 | 440 | 50,000 |
| Greece | 760 | 800 | 50,000 |
| Hungary | 72 | 70 | NA |
| Italy | 60 | 60 | NA |
| Japan | 190 | 200 | NA |
| Turkey | 400 | 450 | NA |
| Other countries | 67 | 70 | NA |
| World total (rounded) | 1,970 | 2,090 | 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 and pumice are alternative soil additives or are sometimes used in conjunction with perlite.

[e]Estimated. NA Not available.
[1]Processed perlite sold and used by producers.
[2]Defined as imports - exports.
[3]See Appendix C for resource/reserve definitions and information concerning data sources.

# PHOSPHATE ROCK

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** Phosphate rock ore was mined by 5 firms at 11 mines in 4 States and processed into to an estimated 27.1 million tons of marketable product valued at $2.4 billion, f.o.b. mine. Florida and North Carolina accounted for about 80% of total domestic output; the remainder was produced in Idaho and Utah. Marketable product refers to beneficiated phosphate rock with phosphorus pentoxide ($P_2O_5$) content suitable for phosphoric acid or elemental phosphorus production. More than 95% of the U.S. phosphate rock mined 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 45% of the wet-process phosphoric acid produced was exported in the form of upgraded granular diammonium and monoammonium phosphate (DAP and MAP, respectively) 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 a variety of food-additive and industrial applications.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, marketable | 25,800 | 28,100 | 30,100 | 31,200 | 27,100 |
| Used by producers | 28,100 | 28,600 | 27,300 | 28,800 | 28,100 |
| Imports for consumption | 2,400 | 3,350 | 3,080 | 2,560 | 2,570 |
| Consumption[1] | 30,500 | 32,000 | 30,400 | 31,300 | 30,600 |
| Price, average value, dollars per ton, f.o.b. mine[2] | 76.69 | 96.64 | 102.54 | 91.11 | 90.00 |
| Stocks, producer, yearend | 5,620 | 4,580 | 6,700 | 9,000 | 6,800 |
| Employment, mine and beneficiation plant, number[e] | 2,300 | 2,260 | 2,230 | 2,170 | 2,100 |
| Net import reliance[3] as a percentage of apparent consumption | 16 | 13 | 3 | 1 | 15 |

**Recycling:** None.

**Import Sources (2010–13):** Morocco, 74%; and Peru, 26%.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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 was estimated to have been lower in 2014 compared with that of 2013, owing to producers drawing from higher than average inventories and the closure of a mine in Florida. Domestic consumption decreased because of lower phosphoric acid and fertilizer production. World production was estimated to be slightly lower in 2014 because of lower output from China.

The leading U.S. phosphate rock producer completed its acquisition of the phosphate assets of another producer in central Florida, adding a fertilizer plant, mine, and processing facility to its assets. The company also closed the last phosphate rock mine in Polk County, FL, in June. This reduced U.S. phosphate rock annual production capacity from 34.7 million tons to 32.7 million tons at 10 active mines. A new mine opened in Idaho in late 2013 as replacement for a mine that had been exhausted. The two other active phosphate rock companies in Idaho are developing new mines to replace existing mines that will be mined out over the next several years. The new mines will be located near the existing facilities in Caribou County, ID.

A Canadian company continued development of a new underground phosphate rock mine in Bear Lake County in southeastern Idaho at the site of several underground phosphate rock mines that operated intermittently from 1907–76. The company expected to begin production in 2015, with an annual production capacity of 900,000 tons.

Prepared by **Stephen M. Jasinski [(703) 648–7711, sjasinsk@usgs.gov]**

# PHOSPHATE ROCK

World phosphate rock production capacity was projected to increase gradually from 225 Mt in 2014 to 258 Mt in 2018. Most of the increase was planned to occur from expansion of existing mines in Morocco and development of a new mine in Saudi Arabia. The rest of the increase was expected from expansion of existing mines in Jordan, Kazakhstan, Peru, Russia, and Tunisia.

World consumption of $P_2O_5$ contained in fertilizers was projected to increase from 42.2 Mt in 2014 to 45.9 Mt in 2018, with the largest growth occurring in Asia and South America.

**World Mine Production and Reserves:** Reserves for Australia were revised by Geoscience Australia to include new mines under development. Reserves for Egypt were revised based on information reported by producers. Canadian reserves were revised to include a new mine under development in Quebec.

| | Mine production | | Reserves[4] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 31,200 | 27,100 | 1,100,000 |
| Algeria | 1,500 | 1,500 | 2,200,000 |
| Australia | 2,600 | 2,600 | 1,030,000 |
| Brazil | 6,000 | 6,750 | 270,000 |
| Canada | 400 | -- | 76,000 |
| China[5] | 108,000 | 100,000 | 3,700,000 |
| Egypt | 6,500 | 6,000 | 715,000 |
| India | 1,270 | 2,100 | 35,000 |
| Iraq | 250 | 250 | 430,000 |
| Israel | 3,500 | 3,600 | 130,000 |
| Jordan | 5,400 | 6,000 | 1,300,000 |
| Kazakhstan | 1,600 | 1,600 | 260,000 |
| Mexico | 1,760 | 1,700 | 30,000 |
| Morocco and Western Sahara | 26,400 | 30,000 | 50,000,000 |
| Peru | 2,580 | 2,600 | 820,000 |
| Russia | 10,000 | 10,000 | 1,300,000 |
| Saudi Arabia | 3,000 | 3,000 | 211,000 |
| Senegal | 800 | 700 | 50,000 |
| South Africa | 2,300 | 2,200 | 1,500,000 |
| Syria | 500 | 1,000 | 1,800,000 |
| Togo | 1,110 | 1,200 | 30,000 |
| Tunisia | 3,500 | 5,000 | 100,000 |
| Vietnam | 2,370 | 2,400 | 30,000 |
| Other countries | 2,580 | 2,600 | 300,000 |
| World total (rounded) | 225,000 | 220,000 | 67,000,000 |

**World Resources:** Some world reserves were reported only in terms of ore 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. Dredge mining of phosphate rock deposits offshore of Namibia and New Zealand were planned to start before 2020. World resources of phosphate rock are more than 300 billion tons.

**Substitutes:** There are no substitutes for phosphorus in agriculture.

[e]Estimated.
[1]Defined as phosphate rock sold or used + imports.
[2]Marketable phosphate rock, weighted value, all grades.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.
[5]Production data for large mines only.

# PLATINUM-GROUP METALS

(Platinum, palladium, rhodium, ruthenium, iridium, osmium)
(Data in kilograms unless otherwise noted)

**Domestic Production and Use:** In 2014, platinum-group metals (PGMs), with an estimated value of nearly $495 million, were produced by one domestic mining company from its Stillwater and East Boulder Mines in south-central Montana. Small quantities of PGMs were also recovered as byproducts of copper refining. The leading demand for PGMs continued to be catalytic converters to decrease harmful emissions from automobiles. PGMs are also used in the glass industry; in jewelry; in the chemical industry for catalysts in nitric acid and other bulk-chemical production, for refining petroleum, and for fabricating laboratory equipment; and in the electronics industry in computer hard disks to increase storage capacity, in multilayer ceramic capacitors, and in hybridized integrated circuits. Platinum and palladium, along with gold-silver-copper-zinc alloys, are used as dental restorative materials. Platinum, palladium, and rhodium are used as investment in the form of exchange-traded products, as well as physical bars and coins.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Mine production:[1] | | | | | |
| Platinum | 3,450 | 3,700 | 3,670 | 3,720 | 3,650 |
| Palladium | 11,600 | 12,400 | 12,300 | 12,600 | 12,200 |
| Imports for consumption: | | | | | |
| Platinum | 152,000 | 129,000 | 172,000 | 116,000 | 130,000 |
| Palladium | 70,700 | 98,900 | 80,100 | 83,100 | 99,000 |
| Rhodium | 12,800 | 13,100 | 12,800 | 11,100 | 11,000 |
| Ruthenium | 14,100 | 13,300 | 10,200 | 15,300 | 11,000 |
| Iridium | 3,530 | 2,790 | 1,230 | 1,720 | 2,500 |
| Osmium | 76 | 48 | 130 | 77 | 235 |
| Exports: | | | | | |
| Platinum | 16,900 | 11,300 | 8,630 | 11,200 | 16,000 |
| Palladium | 38,100 | 32,000 | 32,200 | 25,900 | 24,000 |
| Rhodium | 2,320 | 1,370 | 1,040 | 1,220 | 700 |
| Other PGMs | 3,720 | 1,150 | 1,640 | 1,320 | 1,000 |
| Price,[2] dollars per troy ounce: | | | | | |
| Platinum | 1,615.56 | 1,724.51 | 1,555.39 | 1,489.57 | 1,440.00 |
| Palladium | 530.61 | 738.51 | 649.27 | 729.58 | 830.00 |
| Rhodium | 2,459.07 | 2,204.35 | 1,274.98 | 1,069.10 | 1,180.00 |
| Ruthenium | 198.45 | 165.85 | 112.26 | 75.63 | 67.00 |
| Iridium | 642.15 | 1,035.87 | 1,066.23 | 826.45 | 573.00 |
| Employment, mine, number[1] | 1,350 | 1,570 | 1,660 | 1,770 | 1,660 |
| Net import reliance[3] as a percentage of apparent consumption[e] | | | | | |
| Platinum | 91 | 89 | 90 | 84 | 85 |
| Palladium | 49 | 64 | 57 | 60 | 65 |

**Recycling:** An estimated 155,000 kilograms of platinum, palladium and rhodium was recovered globally from new and old scrap in 2014, including about 50,000 kilograms recovered from automobile catalytic converters in the United States.

**Import Sources (2010–13):** Platinum: Germany, 16%; South Africa, 16%; United Kingdom, 8%; Canada, 7%; and other, 53%. Palladium: Russia, 31%; South Africa, 28%; United Kingdom, 23%; Norway, 5%; and other, 13%.

**Tariff:** All unwrought and semimanufactured forms of PGMs can be imported duty free.

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

**Government Stockpile:** Sales of iridium and platinum from the National Defense Stockpile remained suspended through FY 2014. Iridium inventory decreased by 3 kg from FY13 owing to losses resulting from purity upgrading.

**Stockpile Status—9–30–14[4]**

| Material | Inventory | Disposal Plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|
| Platinum | 261 | — | — |
| Iridium | 15 | — | — |

Prepared by **Patricia J. Loferski [(703) 648–7708, ploferski@usgs.gov]**

# PLATINUM-GROUP METALS

**Events, Trends, and Issues**: Workers at the three leading platinum mining companies in South Africa were on strike to demand higher wages. The strike, which lasted from January until June, was the longest in South Africa's mining history. At least 70,000 workers participated in the strike, which, according to the mining companies, resulted in lost production of about 33,600 kilograms of platinum and lost revenue of about $2.3 billion. Rampup to full production levels was expected to be completed by December. In an effort to return to profitability in the face of increased expenses, one of the PGM producers planned to sell four of its mines.

Production began on schedule in July at one of the expansion projects adjacent to the only U.S. PGM mining company's existing mines. The company entered into a 5-year contract with a refiner whereby the refiner will process all of the PGM filter cake produced and had exclusive rights to purchase all of the mined palladium and a portion of the mined platinum. The mining company scaled back its spending and suspended the review process on its Canadian PGM project owing to an unacceptable rate of return at current metal prices.

A new domestic nickel-copper mine in Michigan began production in September and was expected to produce byproduct PGMs.

Prices of platinum fluctuated during the year, and were not markedly affected by the strikes in South Africa because producers processed PGMs from stocks. In contrast, prices of palladium steadily increased throughout the year, reaching $900 per troy ounce in August for the first time since 2001. Palladium prices were supported by the political crisis in Ukraine, which led to concerns that economic sanctions might be enforced against Russia, the world's leading producer of palladium, and that supply disruptions might occur. Prices for rhodium fluctuated in the first half of the year and spiked in August, when prices were briefly higher than those for platinum for the first time since December 2011, owing to increased investor and industrial demand. Prices for iridium increased throughout the year but the average annual prices for both iridium and ruthenium were below those for 2013.

Automobile production levels were expected to climb, particularly in developing countries, and this was expected to result in increased demand for palladium, platinum, and rhodium, which are used in catalytic converters. Prices were expected to be supported by the robust automobile and industrial demand.

**World Mine Production and Reserves:**

| | Mine production | | | | PGMs |
|---|---|---|---|---|---|
| | Platinum | | Palladium | | Reserves[5] |
| | 2013 | 2014[e] | 2013 | 2014[e] | |
| United States | 3,720 | 3,650 | 12,600 | 12,200 | 900,000 |
| Canada | 7,000 | 7,200 | 16,500 | 17,000 | 310,000 |
| Russia | 25,500 | 25,000 | 80,000 | 81,000 | 1,100,000 |
| South Africa | 131,000 | 110,000 | 75,000 | 60,000 | 63,000,000 |
| Zimbabwe | 12,400 | 11,000 | 9,600 | 10,000 | ([6]) |
| Other countries | 3,780 | 3,800 | 8,900 | 10,000 | 800,000 |
| World total (rounded) | 183,000 | 161,000 | 203,000 | 190,000 | 66,000,000 |

**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:** Less-expensive palladium has been substituted for platinum in most gasoline-engine catalytic converters. About 25% 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. — Zero.
[1]Estimates from published sources.
[2]Engelhard Corporation unfabricated metal.
[3] Defined as imports – exports + adjustments for Government and industry stock changes.
[4] See Appendix B for definitions.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]Included with "Other countries."

# POTASH

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

**Domestic Production and Use:** In 2014, the production value of marketable potash, f.o.b. mine, was about $700 million. Potash was produced in New Mexico and Utah. Most of the production was from southeastern New Mexico, where two companies operated four mines. New Mexico sylvinite and langbeinite ores were beneficiated by flotation, dissolution-recrystallization, heavy-media separation, or combinations of these processes, and provided more than 75% of total U.S. producer sales. In Utah, which has three operations, 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 potassium chloride (muriate of potash or MOP) from byproduct sodium chloride. Two companies processed surface and subsurface brines by solar evaporation and flotation to produce MOP, potassium sulfate (sulfate of potash or SOP), and byproducts.

The fertilizer industry used about 85% of U.S. potash sales, and the chemical industry used the remainder. More than 60% of the potash produced was MOP. Potassium magnesium sulfate (sulfate of potash-magnesia or SOPM) and SOP, which are required by certain crops and soils, also were produced.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production, marketable[1] | 930 | 1,000 | 900 | 960 | 850 |
| Sales by producers, marketable[1] | 1,000 | 990 | 980 | 880 | 950 |
| Imports for consumption | 4,760 | 4,980 | 4,240 | 4,650 | 4,600 |
| Exports | 297 | 202 | 234 | 289 | 100 |
| Consumption:[1, 2] | 5,500 | 5,800 | 5,000 | 5,200 | 5,500 |
| Price, dollars per metric ton of $K_2O$, average, muriate, f.o.b. mine[3] | 630 | 745 | 765 | 720 | 730 |
| Employment, number: | | | | | |
| Mine | 650 | 660 | 750 | 750 | 740 |
| Mill | 700 | 620 | 740 | 740 | 720 |
| Net import reliance[4] as a percentage of apparent consumption | 83 | 83 | 82 | 82 | 84 |

**Recycling:** None.

**Import Sources (2010–13):** Canada, 85%; Russia, 10%; Israel, 2%; Chile, 2%; and other, 1%.

| **Tariff:** Item | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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. |
| Potassium-sodium nitrate mixtures | 3105.90.0010 | Free. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

**Events, Trends, and Issues:** In 2014, domestic and world consumption, sales, and trade increased from those of 2013. Asia and South America were the regions that showed the highest increases in consumption. World production was estimated to have increased owing primarily to increased production in Belarus and Russia. Production in the United States was lower because of the closure of a mine in Michigan in late 2013 and lower production in New Mexico.

A producer in New Mexico announced plans to stop production of MOP in late 2014, because of decreasing ore quality and the age of the processing facility. The company would continue to produce SOPM in New Mexico.

The other active producer in New Mexico began production from a new solar solution mine in 2014. The company planned to ramp up to full production levels of 150,000 to 200,000 tons per year in 2015.

A Canadian company received approval from the U.S. Bureau of Land Management to begin construction of a new underground potash mine in southeastern New Mexico that would produce SOP only. The company planned to begin production in 2017 or 2018, with an annual production capacity of 714,000 tons of SOP.

Prepared by **Stephen M. Jasinski [(703) 648–7711, sjasinsk@usgs.gov]**

# POTASH

In 2014, development of new mines and expansions of existing facilities continued in Argentina, Brazil, Canada, Congo (Brazzaville), Eritrea, Ethiopia, Russia, Turkmenistan, the United Kingdom, and Uzbekistan. Many projects however have been delayed to beyond 2018 because of excess production capacity and lower prices. World potash production capacity was projected to increase to about 61 million tons in 2018 from 55 million tons in 2015. Most of the increases would be from new mines in Canada and Russia and expansions of mines in Belarus, Canada, China, and Russia. Consumption of potash for all uses was projected to increase to 38 million tons in 2018 from 36 million tons in 2015.

Following the dissolution of the marketing agreement between potash producers from Belarus and Russia in July 2013, world potash prices decreased gradually from around $400 per ton MOP to around $300 per ton MOP in April 2014. The price remained level until the fourth quarter of 2014, when prices began to increase slightly.

**World Mine Production and Reserves:** Reserves for Belarus are from official Government sources and may not be comparable to the reserves definition in Appendix C. Reserves for Brazil, Canada, Russia, the United Kingdom, and the United States were from company reports. Reserves for other countries were revised to include Argentina, Congo (Brazzaville), Ethiopia, Laos, and Uzbekistan. The previous report contained reserves data in either recoverable ore or $K_2O$ content, depending on the source. To remain consistent with previously reported data, recoverable ore data and $K_2O$ equivalent are included in reserves when available. Some countries only publish data as $K_2O$ equivalent.

| | Mine production | | Reserves[5] | |
|---|---|---|---|---|
| | 2013 | 2014[e] | Recoverable ore | $K_2O$ equivalent |
| United States[1] | 960 | 850 | 1,700,000 | 200,000 |
| Belarus | 4,240 | 4,300 | 3,300,000 | 750,000 |
| Brazil | 430 | 350 | 300,000 | 50,000 |
| Canada | 10,100 | 9,800 | 4,700,000 | 1,100,000 |
| Chile | 1,050 | 1,100 | NA | 150,000 |
| China | 4,300 | 4,400 | NA | 210,000 |
| Germany | 3,200 | 3,000 | NA | 150,000 |
| Israel | 2,100 | 2,500 | NA | [6]40,000 |
| Jordan | 1,080 | 1,100 | NA | [6]40,000 |
| Russia | 6,100 | 6,200 | 2,800,000 | 600,000 |
| Spain | 420 | 420 | NA | 20,000 |
| United Kingdom | 470 | 470 | NA | 70,000 |
| Other countries | — | 150 | 250,000 | 90,000 |
| World total (rounded) | 34,500 | 35,000 | NA | 3,500,000 |

**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 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 the crop fields.

[e]Estimated. NA. Not available. — Zero.
[1]Data are rounded to no more than two significant digits to avoid disclosing company proprietary data.
[2]Defined as sales + imports – exports.
[3]Average prices based on actual sales; excludes soluble and chemical muriates.
[4]Defined as imports – exports.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]Total reserves in the Dead Sea are arbitrarily 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 2014, domestic production of pumice and pumicite was estimated to be 285,000 tons with an estimated processed value of about $9.98 million, f.o.b. plant. Production took place at 10 operations in 6 States. Pumice and pumicite were mined in Idaho, Oregon, California, New Mexico, Kansas, and Oklahoma, in descending order of production. About 56% of mined pumice was used in the production of construction building block; horticulture consumed 18%; concrete admixture and aggregate, 12%; abrasives, 10%; and the remaining 4% was used for absorbent, filtration, laundry stone washing, and other applications.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production, mine[1] | 241 | 343 | 338 | 269 | 285 |
| Imports for consumption | 34 | 23 | 67 | 72 | 57 |
| Exports[e] | 13 | 14 | 12 | 12 | 15 |
| Consumption, apparent | 262 | 352 | 393 | 329 | 327 |
| Price, average value, dollars per ton, f.o.b. mine or mill | 28.00 | 30.60 | 31.90 | 34.60 | 35.00 |
| Employment, mine and mill, number | 145 | 140 | 140 | 140 | 140 |
| Net import reliance[2] as a percentage of apparent consumption | 8 | 3 | 14 | 18 | 13 |

**Recycling:** Not available.

**Import Sources (2010–13):** Greece, 93%; Iceland, 4%; Mexico, 2%; and other, 1%.

| **Tariff:** **Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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.

Prepared by **Robert D. Crangle, Jr. [(703) 648–6410, rcrangle@usgs.gov]**

# PUMICE AND PUMICITE

**Events, Trends, and Issues:** The amount of domestically produced pumice and pumicite sold or used in 2014 increased to 285,000 tons, compared with 269,000 tons in 2013. Exports increased and imports decreased compared with those of 2013. Approximately 99% of pumice imports originated from Greece and Mexico in 2014, and primarily supplied markets in the eastern and gulf coast regions of the United States. Turkey and Italy are the leading 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. An increase in fuel prices would likely lead to increases in production expenditures; imports and competing materials could become attractive substitutes for domestic products.

All known domestic pumice and pumicite mining in 2014 was accomplished through open pit methods, generally in remote areas where land-use conflicts were not severe. Although the generation and disposal of reject fines in mining and milling resulted in local dust issues at some operations, the environmental impact was restricted to a relatively small geographic area.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[3] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States[1] | 269 | 285 | Large in the United States. Quantitative estimates of reserves for most countries are not available. |
| Algeria[4] | 338 | 350 | |
| Cameroon[4] | 500 | 600 | |
| Chile[4] | 830 | 830 | |
| Ecuador[4] | 675 | 675 | |
| Ethiopia | 300 | 300 | |
| France[4] | 276 | 280 | |
| Greece[4] | 420 | 450 | |
| Guadaloupe | 200 | 200 | |
| Italy[4] | 3,030 | 3,000 | |
| Saudi Arabia[4] | 1,000 | 1,100 | |
| Spain | 195 | 200 | |
| Syria[4] | 500 | 1,000 | |
| Turkey | 5,700 | 5,700 | |
| Other countries[4] | 2,400 | 2,400 | |
| World total (rounded) | 16,600 | 17,400 | |

**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 resources 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 imports – exports.
[3]See Appendix C for resource/reserve definitions and information concerning data sources.
[4]Includes pozzolan and (or) volcanic tuff.

# QUARTZ CRYSTAL (INDUSTRIAL)

(Data in kilograms unless otherwise noted)

**Domestic Production and Use:** Cultured quartz crystal production exists in the United States, but production statistics were not available. Two companies produced cultured quartz crystal. One of these companies uses cultured quartz crystal that has been rejected owing to crystallographic imperfections as feed material. In the past several years, cultured quartz crystal was increasingly produced overseas, primarily in Asia. Electronic applications accounted for most industrial uses of quartz crystal; other uses included special optical applications. Lascas[1] mining and processing in Arkansas ended in 1997.

Virtually all quartz crystal used for electronics was cultured rather than natural crystal. Electronic-grade quartz crystal was essential for making 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 specific import or export statistics on lascas. The U.S. Census Bureau collects import and export statistics on electronic and optical-grade quartz crystal; however, the quartz crystal import and export quantities and values reported were predominantly fused mullite and fused zirconia that was inadvertently reported to be quartz crystal, not including mounted piezoelectric crystals. The price of as-grown cultured quartz was estimated to be $200 per kilogram in 2014. The price of lumbered quartz, which is as-grown quartz that has been processed by sawing and grinding, was estimated to be $400 per kilogram in 2014; however, prices ranged from $20 per kilogram to more than $900 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 (2010–13):** 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 12–31–14 |
|---|---|---|
| Quartz (including lascas) | 2506.10.0050 | Free. |
| Piezoelectric quartz | 7104.10.0000 | 3% ad val. |

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

**Government Stockpile:** As of September 30, 2014, the National Defense Stockpile (NDS) contained 7,134 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 2014. Previously, only individual crystals in the stockpile that weighed 10 kilograms or more and could be used as seed material were sold.

**Stockpile Status—9–30–14**[2]

| Material | Inventory | Disposal Plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|
| Quartz crystal | 7,130 | — | — |

Prepared by **Thomas P. Dolley [(703) 648–7710, tdolley@usgs.gov]**

# QUARTZ CRYSTAL (INDUSTRIAL)

**Events, Trends, and Issues:** Demand for quartz crystal for frequency-control oscillators and frequency filters in a variety of electronic devices should remain stable. However, silicon has replaced quartz crystal in two very important markets—cellular telephones and automotive stability control applications. Future capacity increases to grow quartz crystal may be negatively impacted by this development. 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; however, use of cultured quartz crystal will mean an increased dependence on lascas for growing cultured quartz.

**Substitutes:** Quartz crystal is the best material for frequency-control oscillators and frequency filters 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 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/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 mined by one company in 2014. Bastnäsite, a fluorocarbonate mineral, was mined and processed into concentrates and rare-earth compounds at Mountain Pass, CA. The United States continued to be a net importer of rare-earth products in 2014. The estimated value of rare-earth metals and compounds imported by the United States in 2014 was $210 million, a decrease from $256 million imported in 2013. The estimated distribution of rare earths by end use was as follows, in decreasing order: catalysts, 60%; metallurgical applications and alloys, 10%; permanent magnets, 10%; glass polishing, 10%; and other, 10%.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, bastnäsite concentrates | — | — | 3,000 | 5,500 | 7,000 |
| Imports:[2] | | | | | |
| Compounds: | | | | | |
| Cerium compounds | 1,770 | 1,120 | 1,390 | 1,160 | 1,500 |
| Other rare earth compounds | 10,500 | 6,020 | 3,900 | 8,080 | 10,000 |
| Metals: | | | | | |
| Rare-earth metals, scandium, and yttrium | 525 | 468 | 240 | 393 | 310 |
| Ferrocerium, alloys | 131 | 186 | 267 | 313 | 360 |
| Exports:[2] | | | | | |
| Compounds: | | | | | |
| Cerium compounds | 1,350 | 1,640 | 992 | 734 | 640 |
| Other rare-earth compounds | 1,690 | 3,620 | 1,830 | 5,570 | 5,600 |
| Metals: | | | | | |
| Rare-earth metals, scandium, and yttrium | 1,380 | 3,030 | 2,080 | 1,040 | 160 |
| Ferrocerium, alloys | 3,460 | 2,010 | 951 | 1,420 | 2,100 |
| Consumption, estimated | 15,000 | 11,000 | 15,000 | 15,000 | 17,000 |
| Price, dollars per kilogram, yearend[3]: | | | | | |
| Cerium oxide, 99% minimum | 60–62 | 40–45 | 10–12 | 5–6 | 4–5 |
| Dysprosium oxide, 99% minimum | 285–305 | 1,400–1,420 | 600–630 | 440–490 | 320–360 |
| Europium oxide, 99.9% minimum | 620–640 | 3,780–3,800 | 1,500–1,600 | 950–1,000 | 680–730 |
| Lanthanum oxide, 99% minimum | 59–61 | 50–52 | 9–11 | 6 | 5 |
| Mischmetal, 65% cerium, 35% lanthanum | 57–60 | 47–49 | 14–16 | 9–10 | 9–10 |
| Neodymium oxide, 99% minimum | 86–89 | 190–200 | 75–80 | 65–70 | 56–60 |
| Terbium oxide, 99% minimum | 595–615 | 2,800–2,820 | 1,200–1,300 | 800–850 | 590–640 |
| Employment, mine and mill, annual average | 98 | 146 | 275 | 380 | 394 |
| Net import reliance[4] as a percentage of estimated consumption[e] | 100 | 100 | 80 | 63 | 59 |

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

**Import Sources (2010–13):** Rare-earth compounds and metals: China, 75%; France, 6%; Japan, 6%; Estonia, 4%; and other, 9%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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).

Prepared by **Joseph Gambogi [(703) 648–7718, jgambogi@usgs.gov]**

# RARE EARTHS

**Government Stockpile:** None.

**Events, Trends, and Issues:** In 2014, increased domestic consumption of rare earths was stimulated by lower prices and increased availability of rare-earth compounds. Increased domestic production of separated rare-earth products was hampered by technical difficulties in the rampup of new production capacity. Despite increased global demand for rare earths in the permanent magnet and catalyst industries, prices for most rare-earth compounds declined in 2014 owing to an excess of inventory in the market. Consumption of rare-earths in the phosphor industry decreased owing to the increased use of LED lighting, which requires less rare earths than fluorescent lighting.

Global consumption of rare earths was expected to increase at a compound annual growth rate in excess of 5% from 2014 through 2020. China continued to dominate the global supply of rare earths. In 2014, China's rare-earth export quotas were 31,000 tons, including 27,383 tons for light rare earths and 3,617 tons for heavy rare earths. In August, the World Trade Organization upheld a ruling in favor of the United States, the European Union, and Japan's claims that China violated trade rules with respect to the unfair imposition of export restrictions on rare earths despite China's claims that the controls were aimed at protecting the environment and conserving resources. China continued efforts to consolidate its rare-earths industry and clamp down on illegal production and exports. China's State Bureau of Material Reserve continued to expand its stockpile of rare earths.

Exploration efforts to develop rare-earth projects continued in 2014. Exploration and development assessments in the United States included Bear Lodge, WY; Bokan Mountain, AK; Diamond Creek, ID; Elk Creek, NE; La Paz, AZ; Lemhi Pass, ID-MT; Pea Ridge, MO; Round Top, TX; and Thor, NV. Additional projects were underway in Australia, Brazil, Canada, China, Finland, Greenland, India, Kyrgyzstan, Madagascar, Malawi, Mozambique, Namibia, South Africa, Sweden, Tanzania, Turkey, and Vietnam.

**World Mine Production and Reserves:** U.S. reserves were revised to include only those reserves compliant with recognized standards. This resulted in a large reduction in the U.S. reserves reported in 2015 compared to previous years. Domestic reserves include an estimated 1.5 million tons at Mountain Pass that were compliant with the Securities and Exchange Commission's Industry Guide 7 and 390,000 tons of reserves at the Bear Lodge deposit in Wyoming compliant with Canada's National Instrument 43-101 standard. The reserves reported for other countries will transition to stricter standards as better information becomes available.

| | Mine production[e] | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014 | |
| United States | 5,500 | 7,000 | 1,800,000 |
| Australia | 2,000 | 2,500 | [6]3,200,000 |
| Brazil | 330 | — | 22,000,000 |
| China | 95,000 | 95,000 | 55,000,000 |
| India | 2,900 | 3,000 | 3,100,000 |
| Malaysia | 180 | 200 | 30,000 |
| Russia | 2,500 | 2,500 | ([7]) |
| Thailand | 800 | 1,100 | NA |
| Vietnam | 220 | 200 | ([7]) |
| Other countries | NA | NA | 41,000,000 |
| World total (rounded) | 110,000 | 110,000 | 130,000,000 |

**World Resources:** Rare earths are relatively abundant in the Earth's crust, but discovered minable concentrations are less common than for most other ores. U.S. and world resources are contained primarily in bastnäsite and monazite. Bastnäsite deposits in China and the United States constitute the largest percentage of the world's rare-earth economic resources, and monazite deposits constitute the second largest segment.

**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 contents of various materials were estimated. Source: U.S. Census Bureau.
[3]Price range from Metal-Pages Ltd.
[4]Defined as estimated consumption – production. Insufficient data were available to determine stock changes and unattributed imports and exports of rare-earth materials.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]For Australia, Joint Ore Reserves Committee (JORC)-compliant reserves were about 2.2 million tons.
[7]Included with "Other countries."

# RHENIUM

(Data in kilograms of rhenium content unless otherwise noted)

**Domestic Production and Use:** During 2014, ores containing rhenium were mined at seven operations (four in Arizona, and one each in Montana, New Mexico, 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 use of rhenium were in superalloys used in high-temperature turbine engine components and in petroleum-reforming catalysts, representing an estimated 70% and 20%, 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-based 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 estimated value of rhenium consumed in 2014 was about $90 million.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production[1] | 6,100 | 8,610 | 7,910 | 7,100 | 7,900 |
| Imports for consumption | 33,600 | 33,500 | 40,200 | 35,300 | 37,500 |
| Exports | NA | NA | NA | NA | NA |
| Consumption, apparent | 39,700 | 42,100 | 48,100 | 42,400 | 45,400 |
| Price,[2] average value, dollars per kilogram, gross weight: | | | | | |
| Metal pellets, 99.99% pure | 4,720 | 4,670 | 4,040 | 3,160 | 3,000 |
| Ammonium perrhenate | 4,630 | 4,360 | 3,990 | 3,400 | 3,100 |
| Employment, number | Small | Small | Small | Small | Small |
| Net import reliance[3] as a percentage of apparent consumption | 85 | 80 | 84 | 83 | 83 |

**Recycling:** Molybdenum-rhenium and tungsten-rhenium scrap continued to be processed by a growing number of companies, mainly in the United States and Germany. All spent platinum-rhenium catalysts were recycled.

**Import Sources (2010–13):** Rhenium metal powder: Chile, 88%; Poland, 7%; United Kingdom, 2%; and other, 3%. Ammonium perrhenate: Republic of Korea, 39%; Kazakhstan, 31%; Germany, 8%; Poland, 6%; and other, 16%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Salts of peroxometallic acids, other— ammonium perrhenate | 2841.90.2000 | 3.1% ad val. |
| Rhenium, etc., (metals) waste and scrap | 8112.92.0600 | Free. |
| Rhenium, (metals) unwrought; powders | 8112.92.5000 | 3% ad val. |
| Rhenium, etc., (metals) wrought; etc. | 8112.99.9000 | 4% ad val. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **Désirée E. Polyak [(703) 648–4909, dpolyak@usgs.gov]**

# RHENIUM

**Events, Trends, and Issues:** During 2014, the United States continued to rely on imports for much of its supply of rhenium, and Chile, Kazakhstan, and the Republic of Korea supplied most of the imported rhenium. Rhenium imports for consumption increased by 6% from those of 2013. Primary rhenium production in the United States increased 11% from that of 2013. Kazakhstan's only current rhenium producer, Kazakhmys plc, temporarily suspended its operations in mid-2013 at its Zhezkazgan smelter and refinery. The company expected to upgrade the facility to process copper-molybdenum ore from the newly developed Bozshakol mining and concentrating complex in Kazakhstan.

In 2014, the average catalytic-grade APR price remained at $3,150 per kilogram until July, when the price further decreased to an average of $3,000 per kilogram and remained at that level until yearend. Average rhenium metal pellet price remained at $3,000 per kilogram during 2014.

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. However, the major aerospace companies were expected to continue testing superalloys that contain one-half the rhenium used in currently designed engine blades, as well as testing rhenium-free alloys for other engine components. New technology continued to be developed to allow recycling of superalloy scrap. Secondary rhenium recycling rates continued to increase worldwide.

**World Mine Production and Reserves:**

| | Mine production[4] | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 7,100 | 7,900 | 390,000 |
| Armenia | 300 | 300 | 95,000 |
| Canada | — | — | 32,000 |
| Chile[6] | 25,000 | 26,000 | 1,300,000 |
| Kazakhstan | 2,500 | — | 190,000 |
| Peru | — | — | 45,000 |
| Poland | 7,530 | 7,600 | NA |
| Russia | NA | NA | 310,000 |
| Uzbekistan | 5,500 | 5,000 | NA |
| Other countries | 1,000 | 2,000 | 91,000 |
| World total (rounded) | 48,900 | 48,800 | 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 is also 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 the copper smelter.

**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 $MoS_2$ concentrates.
[2]Average price per kilogram of rhenium in pellets or catalytic-grade ammonium perrhenate, from Metal Bulletin.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]Estimated amount of rhenium recovered in association with copper and molybdenum production.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]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. One company recovered and stockpiled for sale approximately 200 tons of rubidium as part of ongoing reclamation projects in Arizona, Idaho, and Utah. 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 and lepidolite mining and is imported from other countries for processing in the United States. The United States sources the majority of pollucite from the largest known North American deposit at Bernic Lake, Manitoba, Canada.

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 the treatment of epilepsy, thyroid disorder, and antishock agents; rubidium-82, a radioactive isotope, is used as a blood-flow tracer in positron emission tomographic imaging; and rubidium chloride is 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. 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 within a decade.

Rubidium's photo emissive 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 (GPS). Rubidium-rich feldspars are used in ceramic applications for spark plugs and electrical insulators because of their high dielectric capacity. Rubidium hydroxide is used in fireworks to oxidize mixtures and produce violet hues. The U.S. military frequency standard, the United States Naval Observatory (USNO) Time Scale, is based on 48 weighted atomic clocks, including four 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 sourced primarily from Canada, was exported to the United States for further processing. Industry information during the last decade suggests an annual domestic consumption rate of approximately 2,000 kg.

No market price for rubidium is published because the metal is not traded in commercial quantities. In 2014, one company offered 1-gram ampoules of 99.75%-grade rubidium (metal basis) for $80.30 and 100 grams ampoules of the same material for $1,472.00, a 4% increase from that of 2013. The price for 10-gram ampoules of 99.8% rubidium formate hydrate (metal basis) was $56.20, a 4% increase from that of 2013. The price for 10-gram ampoules of 99.8% and 99.975% rubidium chloride (metal basis) was $55.10 and $209.00, respectively.

**Recycling:** None.

**Import Sources (2010–13):** The United States is 100% import reliant on byproduct rubidium-concentrate imports, most of which was thought to be imported from Canada.

**Tariff:**

| Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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.

Prepared by **Christopher A. Tuck [(703) 648–4912, ctuck@usgs.gov]**

# RUBIDIUM

**<u>Events, Trends, and Issues</u>:** Domestic rubidium occurrences will remain uneconomic unless market conditions change, such as the discovery of new end uses or increased consumption for existing end uses, which in turn would lead to increased prices. No known human health issues are associated with naturally occurring rubidium, and its use has minimal environmental impact.

As reported in 2014, one underground mining operation at Bernic Lake, Manitoba, Canada, experienced a fall of ground in early 2013, in the area of the mine's crowning pillar, following a similar event in 2010. A site review was conducted in April 2013, by a third-party engineering consulting service, which indicated the crown pillar had a 55% probability of substantive, progressive failure within the next year and a 25% probability failure occurring in the next 6 months. Monitoring equipment had been installed to monitor the mines stability. Development alternatives that could require 2 to 3 years to complete were being assessed to allow for continued long-term mining operations. Collapse of the mine would result in enduring mining delays and, potentially, mine closure. In Argentina, one company began bulk sampling and drilling to determine resource estimates for a cesium and rubidium deposit. The deposit underwent pre-feasibility studies with expected reserves estimates to be complete by yearend 2014. Initial studies indicated a cesium-to-rubidium ratio of 8:1.

Developments continued in quantum computing and related fields of research, including a method for connecting particles, which would be used as a switch in computing processes and internet connections. The process involves a photon of light and a rubidium atom altering the quantum state of one another, a substantial discovery integral in moving quantum computers towards the prototype stage. The National Institute of Standards and Technology developed a microfluid chip that produces and detects xenon gasses, using rubidium atoms to polarize the xenon atoms and enhance the signal strength. The chip could be used as a smaller and cheaper replacement for some instruments, like magnetic resonance imaging, which rely on nuclear magnetic resonance.

An accelerometer, based on the quantum interference of rubidium utlracold atoms, was being developed for use on submarines in the Royal Navy, among similar developments in other countries. The device would allow submarines to track their own locations within a 1-meter error in a 24-hour period; submarines can currently only navigate using traditional GPS, which requires surfacing. The technology, upon miniaturization, could also be adapted for use to explore oil or mineral deposits and as gravity scanners, which can create density maps of an object's contents.

**<u>World Mine Production and Reserves</u>:** One mine in Canada produced rubidium ore as a byproduct, which was processed as concentrate; however, production data for that mine are not available. The principal sources of global rubidium reserves, lepidolite and pollucite, can contain up to 3.5% rubidium oxide and 1.5%, respectively. The rubidium-bearing mineral reserves are found in zoned pegmatites, which are exceptionally coarse-grained plutonic rocks that formed late in the crystallization of a silicic magma. Mineral reserves exist globally, but extraction and concentration are cost prohibitive. Production is known to occur periodically in Canada, Namibia, and Zimbabwe but production data were not available. Rubidium is also mined in China, but information regarding reserves and production is unavailable.

| | **Reserves**[1] |
|---|---:|
| Canada | 12,000 |
| Namibia | 50,000 |
| Zimbabwe | 10,000 |
| Other countries | 8,000 |
| World total | 80,000 |

**<u>World Resources</u>** 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, and 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).

**<u>Substitutes</u>:** 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/reserve definitions and information concerning data sources.

# SALT

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** Domestic production of salt increased by 9% in 2014 to 44.1 million tons. The total value was estimated to be about $2.2 billion. Twenty-eight companies operated 61 plants in 16 States. Five of the seven leading States were, in descending order of total salt sold or used, Louisiana with 33%; Texas, 18%; New York, 17%; Kansas, 6%; and Utah, 5%. Ohio and Michigan were among the top seven leading States in total salt sold or used but their rankings are withheld to protect proprietary data. The estimated percentage of salt sold or used was, by type, rock salt, 42%; salt in brine, 40%; vacuum pan, 10%; and solar salt, 8%.

Highway deicing consumed about 43% of total salt. The chemical industry accounted for about 38% of total salt sales with salt in brine accounting for 91% of the salt used for chemical feedstock. The chlorine and caustic soda manufacturing sector was the main consumer within the chemical industry. The remaining markets for salt were, in declining order, distributors, 8%; food processing, 4%; agricultural, 3%; general industrial, 2%; and other uses combined with exports and primary water treatment, 1% each.

| **Salient Statistics—United States:**[1] | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production | 43,300 | 45,000 | 37,200 | 40,300 | 44,100 |
| Sold or used by producers | 43,500 | 45,500 | 34,900 | 43,400 | 44,500 |
| Imports for consumption | 12,900 | 13,800 | 9,880 | 11,900 | 18,000 |
| Exports | 595 | 846 | 809 | 525 | 850 |
| Consumption: | | | | | |
| Reported | 48,600 | 48,000 | 36,900 | 47,600 | 54,000 |
| Apparent[2] | 55,800 | 58,500 | 44,000 | 54,800 | 61,600 |
| Price, average value of bulk, pellets and packaged salt, dollars per ton, f.o.b. mine and plant: | | | | | |
| Vacuum and open pan salt | 180.08 | 174.00 | 169.93 | 178.65 | 180.00 |
| Solar salt | 57.41 | 51.19 | 71.87 | 81.36 | 83.00 |
| Rock salt | 35.67 | 38.29 | 36.89 | 47.24 | 55.00 |
| Salt in brine | 7.49 | 8.14 | 8.44 | 8.49 | 8.50 |
| Employment, mine and plant, number[e] | 4,100 | 4,100 | 4,100 | 4,100 | 4,200 |
| Net import reliance[3] as a percentage of apparent consumption | 24 | 22 | 22 | 21 | 28 |

**Recycling:** None.

**Import Sources (2010–13):** Canada, 38%; Chile, 36%; Mexico, 11%; The Bahamas, 5%; and other, 10%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Salt (sodium chloride) | 2501.00.0000 | Free. |

**Depletion Allowance:** 10% (Domestic and foreign).

**Government Stockpile:** None.

**Events, Trends, and Issues:** The 2013–14 winter was colder than the 2012–13 winter, and the amount of frozen precipitation and the number of winter weather events were above normal in many parts of the United States, requiring more salt for highway deicing. Rock salt production and imports in 2014 increased significantly from the levels in 2013 because many municipalities and local and State transportation departments reported low levels of rock salt inventories at the end of the last winter season. Many contracts between salt suppliers and consumers require that the customer take delivery of at least 80 percent of its order, and because of the greatly increased demand for deicing salt, many buyers were experiencing double-digit percentage increases in rock salt prices in these contracts. Salt purchasers without contracts are subject to substantial spikes in pricing if they require an emergency salt allocation.

Prepared by **Wallace P. Bolen [(703) 648–7727, wbolen@usgs.gov]**

# SALT

The majority of local and State governments in cold regions reportedly had stockpiled some supplies of rock salt for the winter of 2014–15, but many had less than was typical and some were struggling to find supplies even as winter weather arrived early in many parts of the United States. The National Oceanic and Atmospheric Administration predicted that the likelihood of a repeat of the previous harsh winter was unlikely. The forecast for the traditional snowbelt in the northern tier of the United States was uncertain, with an above- or below-average winter equally likely. However, the southern part of the United States was expected to be cooler than average, and the West and New England were likely to be warmer than average. It was anticipated that the domestic salt industry would be able to provide adequate salt supplies from domestic and foreign sources for emergency use in the event of adverse winter weather.

**World Production and Reserves**:

| | Production | | Reserves[4] |
|---|---|---|---|
| | **2013** | **2014[e]** | |
| United States[1] | 40,300 | 44,100 | 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 | 7,500 | 7,500 | |
| Canada | 12,200 | 13,300 | |
| Chile | 6,580 | 8,000 | |
| China | 70,000 | 71,000 | |
| France | 6,100 | 6,000 | |
| Germany | 11,900 | 12,000 | |
| India | 16,000 | 17,000 | |
| Mexico | 10,800 | 9,500 | |
| Poland | 4,430 | 4,400 | |
| Spain | 4,440 | 4,500 | |
| Turkey | 5,300 | 5,400 | |
| Ukraine | 6,200 | 5,400 | |
| United Kingdom | 6,700 | 6,800 | |
| Other countries | 42,200 | 43,400 | |
| World total (rounded) | 262,000 | 269,000 | |

**World Resources:** World continental resources of salt are practically unlimited, and the salt content in the oceans is virtually inexhaustible. Domestic resources of rock salt and salt from brine are primarily in the States of Kansas, Louisiana, Michigan, New York, Ohio, and Texas. Saline lakes and solar evaporation salt facilities are in the States of 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/reserve definitions and information concerning data sources.

# SAND AND GRAVEL (CONSTRUCTION)[1]

(Data in million metric tons unless otherwise noted)[2]

**Domestic Production and Use:** Construction sand and gravel valued at $7 billion was produced by an estimated 4,100 companies and government agencies from about 6,600 operations in 50 States. Leading producing States were, in order of decreasing tonnage, Texas, California, Minnesota, Washington, Michigan, Colorado, Arizona, North Dakota, Wisconsin, and Ohio, which together accounted for about 55% 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, 657 million tons shipped for consumption in the first 9 months of 2014, was 8% higher than the 596 million tons estimated for the same period in 2013. Additional production information by quarter for each State, geographic region, and the United States is published by the U.S. Geological Survey (USGS) in its quarterly Mineral Industry Surveys for Crushed Stone and Sand and Gravel.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production | 807 | 808 | 812 | [e]847 | 911 |
| Imports for consumption | 3 | 3 | 4 | 3 | 3 |
| Exports | ([3]) | ([3]) | ([3]) | ([3]) | ([3]) |
| Consumption, apparent | 809 | 811 | 816 | [e]850 | 914 |
| Price, average value, dollars per ton | 7.30 | 7.43 | 7.74 | [e]7.58 | 7.70 |
| Employment, mines, mills, and shops, number | 29,500 | 29,800 | 30,600 | 30,000 | 30,500 |
| Net import reliance[4] as a percentage of apparent consumption | ([3]) | ([3]) | ([3]) | ([3]) | ([3]) |

**Recycling:** Recycling of asphalt road surface layers, cement concrete surface layers, and concrete structures was increasing, although it was still a small percentage of aggregates consumption.

**Import Sources (2010–13):** Canada, 79%; Mexico, 7%; The Bahamas, 5%; and other, 9%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Sand, silica and quartz, less than 95% silica | 2505.10.5000 | Free. |
| Sand, other | 2505.90.0000 | Free. |
| Pebbles and gravel | 2517.10.0015 | Free. |

**Depletion Allowance:** Common varieties, 5% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **Shawnna M. Bennett [(703) 648–7715, smbennett@usgs.gov]**

# SAND AND GRAVEL (CONSTRUCTION)

**Events, Trends, and Issues:** With U.S. economic activity gradually improving, construction sand and gravel output for 2014 increased about 8% compared with that of 2013. According to the U.S. Census Bureau of the Department of Commerce, construction spending in the United States for the first 10 months of 2014 increased by about 3% compared to the same period in 2013. These numbers are also reflected in the quarterly reports with a steady increase over the last five quarters in sand and gravel sales, but levels still have not reached those in 2008.

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, driven by regulations and local sentiment. Resultant regional shortages of construction sand and gravel could thus result in higher-than-average price increases in industrialized and urban areas.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[5] |
|---|---|---|---|
| | 2013[e] | 2014[e] | |
| United States | 847 | 911 | Reserves are controlled largely by land use and (or) environmental concerns. |
| Other countries[6] | NA | NA | |
| World total | NA | NA | |

**World Resources:** Sand and gravel resources of the world are plentiful. However, because of environmental restrictions, 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 small in 2014.

[e]Estimated. NA Not available.
[1]See also Sand and Gravel (Industrial) and Stone (Crushed).
[2]See Appendix A for conversion to short tons.
[3]Less than ½ unit.
[4]Defined as imports – exports.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]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 country chapters of the USGS Minerals Yearbook.

# SAND AND GRAVEL (INDUSTRIAL)[1]

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** In 2014, industrial sand and gravel valued at about $4.2 billion was produced by 118 companies from 183 operations in 33 States. The value of production of industrial sand and gravel in 2014 increased by 20% over the previous year. Leading States were, in order of tonnage produced, Wisconsin, Illinois, Texas, Minnesota, Arkansas, Oklahoma, Missouri, and Iowa. Combined production from these States accounted for 78% of the domestic total. About 72% of the U.S. tonnage was used as hydraulic fracturing sand and well-packing and cementing sand, 13% as glassmaking sand, 6% as foundry sand, 3% as whole-grain fillers and building products, 2% as other whole-grain silica, 2% as ground and unground sand for chemicals, and 2% for other uses.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production | 32,300 | 43,800 | 50,600 | 62,100 | 75,000 |
| Imports for consumption | 132 | 316 | 306 | 160 | 280 |
| Exports | 3,950 | 4,330 | 4,360 | 2,960 | 3,000 |
| Consumption, apparent | 28,500 | 39,800 | 46,600 | 59,300 | 72,300 |
| Price, average value, dollars per ton | 35.63 | 45.74 | 52.80 | 55.80 | 56.00 |
| Employment, quarry and mill, number[e] | 3,000 | 3,000 | 3,500 | 3,800 | 4,000 |
| Net import reliance[2] 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 (2010–13):** Canada, 77%; Mexico, 18%; and other, 5%.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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 about 72.3 million tons in 2014, a 22% increase from that of the previous year. Mine output was sufficient to accommodate many uses, which included ceramics, chemicals, fillers (ground and whole grain), container, filtration, flat and specialty glass, foundry, hydraulic fracturing, and recreational uses. Strong demand for hydraulic fracturing sand to support production of natural gas and petroleum from shale deposits has led to production capacity upgrades and ongoing permitting and opening of new mines. New and more efficient hydraulic fracturing techniques, which require more silica sand use per well, will further increase demand for hydraulic fracturing sand. Although the United States remains a net exporter of industrial sand and gravel, imports in 2014 increased to about 280,000 tons from 160,000 tons in 2013. 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). Exports of industrial sand and gravel increased slightly in 2014 compared with those of 2013.

Prepared by **Thomas P. Dolley [(703) 648–7710, tdolley@usgs.gov]**

# SAND AND GRAVEL (INDUSTRIAL)

The United States was the world's leading producer and consumer of industrial sand and gravel based on estimated world production figures. It was difficult to collect definitive data on silica sand and gravel production in most nations because of the wide range of terminology and specifications from country to country. 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.

The industrial sand and gravel industry continued to be concerned with safety and health regulations and environmental restrictions in 2014, especially those concerning crystalline silica exposure. The Occupational Safety and Health Administration was formulating new regulations to further restrict exposure to crystalline silica at mine sites, to be implemented in the near future. Local shortages of industrial sand and gravel were expected to continue to increase owing to local zoning regulations and land development alternatives, 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 situations are expected to cause future sand and gravel operations to be located farther from high-population centers.

**World Mine Production and Reserves:**

| | Mine production[e] | | Reserves[3] |
|---|---|---|---|
| | 2013 | 2014 | |
| United States | 62,100 | 75,000 | Large. Industrial sand and gravel deposits are widespread. |
| Australia | 5,500 | 5,500 | |
| Canada | 1,690 | 1,800 | |
| Chile | 1,360 | 1,400 | |
| Czech Republic | 1,340 | 1,340 | |
| Finland | 2,400 | 2,400 | |
| France | 6,290 | 6,300 | |
| Germany | 7,500 | 7,500 | |
| India | 1,210 | 1,200 | |
| Italy | 16,400 | 16,400 | |
| Japan | 3,000 | 3,000 | |
| Malaysia | 1,000 | 1,000 | |
| Mexico | 3,590 | 3,590 | |
| Moldova | 3,000 | 3,000 | |
| Norway | 1,000 | 1,000 | |
| Poland | 2,300 | 2,300 | |
| Saudi Arabia | 1,400 | 1,400 | |
| South Africa | 2,110 | 2,100 | |
| Spain | 3,400 | 3,400 | |
| Turkey | 15,000 | 15,000 | |
| United Kingdom | 3,760 | 3,800 | |
| Other countries | 6,690 | 7,000 | |
| World total (rounded) | 152,000 | 165,000 | |

**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 sandstones, 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, 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 imports – exports + adjustments for Government and industry stock changes.

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

# SCANDIUM[1]

(Data in kilograms of scandium oxide content unless otherwise noted)

**Domestic Production and Use:** Domestically, scandium-bearing minerals have been neither mined nor recovered from mine tailings in 2014. Domestic capacity to produce ingot and distilled scandium metal was at three facilities in Ames, IA; Phoenix, AZ; and Urbana, IL. The principal source for scandium metal and scandium compounds was imports from China.

The principal uses for scandium in 2014 were in solid oxide fuel cells (SOFCs) and aluminum-scandium alloys. Other uses for scandium included ceramics, electronics, lasers, lighting, and radioactive isotopes. In SFOCs, 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. Scandium-aluminum 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 were used as a tracing agent in oil refining.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Price, yearend, dollars: | | | | | |
| Compounds, per gram: | | | | | |
| Acetate, 99.9% purity, 5-gram sample size[2] | 47.00 | 48.40 | 50.10 | 51.90 | 43.00 |
| Chloride, 99.9% purity, 5-gram sample size[2] | 62.40 | 138.00 | 143.00 | 148.00 | 123.00 |
| Fluoride, 99.9% purity, 5-gram sample size[2] | 229.00 | 235.80 | 244.00 | 253.00 | 263.00 |
| Iodide, 99.999% purity, 5-gram sample size[2] | 207.00 | 213.00 | 220.00 | 228.00 | 187.00 |
| Oxide, 99.99% purity, 5-kilogram lot size[3] | 1.62 | 4.70 | 4.70 | 5.00 | NA |
| Metal: | | | | | |
| Scandium, distilled dendritic, per gram, 2-gram sample size[3] | 193.00 | 199.00 | 206.00 | 213.00 | 221.00 |
| Scandium, ingot, per gram, 5-gram sample size[3] | 158.00 | 163.00 | 169.00 | 175.00 | 134.00 |
| Scandium-aluminum alloy, per kilogram, metric-ton lot size[2] | 74.00 | 220.00 | 220.00 | 155.00 | NA |
| Net import reliance[4] as a percentage of apparent consumption | 100 | 100 | 100 | 100 | 100 |

**Recycling:** None.

**Import Sources (2010–13):** Although no definitive data exist listing import sources, imported material is mostly from China.

| **Tariff:** **Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| Rare-earth metals, scandium and yttrium, whether or not intermixed or interalloyed, including scandium | 2805.30.0000 | 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 rare-earth carbonates, other, including scandium | 2846.90.8075 | 3.7% ad val. |
| Other rare-earth compounds, including scandium | 2846.90.8090 | 3.7% ad val. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **Joseph Gambogi [(703) 648–7718, jgambogi@usgs.gov]**

# SCANDIUM

**Events, Trends, and Issues:** The global supply and consumption of scandium was estimated to be about 10 to 15 tons per year. Consumption of scandium contained in SOFCs was reported to be increasing. Prices for small samples of scandium metal and scandium compounds varied significantly, but generally decreased compared with those in 2013. Published prices for scandium oxide and scandium-aluminum alloys were not available. The global scandium market remained very small relative to most other metals.

In New South Wales, Australia, a preliminary economic assessment of the Nyngan scandium project was completed. The assessment concluded the project had the potential to produce 36 metric tons of scandium oxide per year using high pressure acid leach and solvent extraction techniques. In Northern Queensland, Australia, measured and indicated resources of a scandium-cobalt-nickel deposit near Greenvale were estimated to include 3,970 tons of scandium oxide, using a 1% nickel-equivalent cut-off grade. If developed, the deposit could become a leading source of scandium.

In Japan, efforts were underway to recover scandium and other metals from a titanium dioxide pigment production facility. If a pilot-plant study is successful, the proprietary technology could be scaled up and employed on other titanium dioxide production facilities.

In the Philippines, a 10-kilogram-per-month pilot-plant study planned to recover scandium oxide following the leaching of nickel laterite for nickel-cobalt sulfide. A commercial scale plant was contemplated for 2015.

In Russia, an aluminum producer was conducting a pilot-plant study to produce scandium concentrate from red mud (a residue generated during the production of aluminum). The plant was reported to be capable of producing 2.5 tons per year of concentrate. Additional plans called for an additional 500-kilogram-per-year pilot plant to process the scandium concentrate into scandium oxide. In Lermontov, Kurgan region, a pilot study was underway to recover scandium as a byproduct of uranium production.

**World Mine Production and Reserves:**[5] 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 in 2014 were not available.

**World Resources:** Resources of scandium are abundant in relation to demand. Scandium is rarely concentrated in nature because of its lack of affinity for the common ore-forming anions. It is widely dispersed in the lithosphere and forms solid solutions in more than 100 minerals.

Scandium that was previously produced domestically was primarily from the scandium-yttrium silicate mineral thortveitite and from byproduct leach solutions from uranium operations. One of the principal domestic scandium resources is the fluorite tailings from the mined-out Crystal Mountain deposit near Darby, MT. Resources also are contained in the tantalum residues previously processed at Muskogee, OK. Smaller resources are associated with molybdenum, titanium, and tungsten minerals in Colorado and in scandium-bearing aluminum phosphate minerals in Utah. Other lower grade domestic resources are present in ores of aluminum, cobalt, iron, molybdenum, nickel, phosphate, tantalum, tin, titanium, tungsten, zinc, and zirconium. There are identified scandium resources in Australia, China, Kazakhstan, Madagascar, Norway, Russia, and Ukraine.

**Substitutes:** Titanium and aluminum high-strength alloys, as well as carbon fiber materials, may substitute in high-performance scandium-alloy applications. Light-emitting diodes, also known as LEDs, displace halide and fluorescent lighting in industrial and residential applications. In some applications that rely on scandium's unique properties, substitution is not possible.

[e]Estimated. NA Not available.
[1]See also Rare Earths.
[2]Prices from Alfa Aesar, a Johnson Matthey company.
[3]Prices from Stanford Materials Corp.
[4]Defined as imports – exports + adjustments for stock changes.
[5]See Appendix C for resource/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 three electrolytic refineries operating in the United States, one in Texas reported production of primary selenium, one exported semirefined selenium for toll refining in Asia, and one generated selenium-containing slimes that were exported for processing.

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 and gun bluing; in rubber compounding chemicals; in the electrolytic production of manganese to increase yields; and in brass alloys to improve machinability. It is used as a metallurgical additive to improve machinability of copper, lead, and steel alloys, and in thin-film photovoltaic copper indium gallium diselenide (CIGS) solar cells.

Selenium is used as a human dietary supplement and in antidandruff shampoos. The leading agricultural uses are as a dietary supplement for livestock and as a fertilizer additive to enrich selenium-poor soils.

Estimates for world consumption are as follows: metallurgy, 40%; glass manufacturing, 25%; agriculture, 10%; chemicals and pigments, 10%; electronics, 10%; and other uses, 5%.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, refinery | W | W | W | W | W |
| Imports for consumption, metal and dioxide | 480 | 601 | 460 | 442 | 520 |
| Exports, metal, waste and scrap | 857 | 1,350 | 952 | 648 | 500 |
| Consumption, apparent | W | W | W | W | W |
| Price, dealers, average, dollars per pound, 100-pound lots, refined | 37.83 | 66.35 | 54.47 | 36.17 | 27.00 |
| Stocks, producer, refined, yearend | W | W | W | W | W |
| Net import reliance[1] 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 (2010–13):** Japan, 18%; China, 18%; Belgium, 17%; Philippines, 10%; and other, 37%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–13 |
|---|---|---|
| Selenium metal | 2804.90.0000 | Free. |
| Selenium dioxide | 2811.29.2000 | Free. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **C. Schuyler Anderson [(703) 648–4985, csanderson@usgs.gov]**

# SELENIUM

**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. In the first 9 months of 2014, the price of selenium remained relatively stagnant, ranging from $24.0 per pound to $27.5 per pound. The estimated annual average price of $27.0 per pound is a 75% decline from its all-time high value of $80 per pound in 2011. China's manganese industry, the leading consumer of selenium, remained stagnant, and operated at about a 40% utilization rate.

In China, the Fanya Metal Exchange, the leading global exchange for rare metals, started trading selenium (99.9% grade) on April 21, 2014. Following the start of trading, the reported dealer price rose slightly; however, by July, it had returned to its previous level. Domestic and global use of selenium in glass remained unchanged because of stagnant glass production. The use of selenium in fertilizers and supplements in the plant-animal food chain and as a human vitamin supplement also was unchanged. Selenium consumption in CIGS solar cells decreased in 2014, owing to improvements in silicon-based solar panels that continued to make them more cost effective than CIGS solar cells. As of the beginning of October, the Fanya warehouses held about 205 metric tons of selenium, and had a storage capacity of 1,000 metric tons.

**World Refinery Production and Reserves:** Selenium reserves in China were estimated based on selenium content of Chinese copper reserves; however, production estimates for China were not available.

| | Refinery production[2] | | Reserves[3] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | W | W | 10,000 |
| Belgium | 200 | 200 | — |
| Canada | 159 | 150 | 6,000 |
| Chile | 75 | 70 | 25,000 |
| China | NA | NA | 26,000 |
| Finland | 100 | 75 | — |
| Germany | 700 | 700 | — |
| Japan | 760 | 760 | — |
| Peru | 50 | 40 | 13,000 |
| Poland | 90 | 80 | 3,000 |
| Russia | 150 | 150 | 20,000 |
| Other countries | [4]50 | [4]50 | 21,000 |
| World total (rounded) | [5]NA | [5]NA | 120,000 |

**World Resources:** Reserves for selenium are based on identified copper deposits. 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, although technically feasible, does not appear likely to be economical in the foreseeable future.

**Substitutes:** High-purity silicon has replaced selenium in high-voltage rectifiers. Silicon is also the major substitute for selenium in low- and medium-voltage rectifiers and solar photovoltaic cells. 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.

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 power cells.

[e]Estimated. E Net exporter. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Defined as imports – exports + adjustments for Government and industry stock changes.
[2]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.
[3]Appendix C for resource/reserve definitions and information concerning data sources.
[4]Includes India, Serbia, and Sweden.
[5]Australia, China, Iran, Kazakhstan, Mexico, the Philippines, and Uzbekistan are known to produce refined selenium, but output is not reported, and information is inadequate for formulation of reliable production estimates. Total world production is not shown because of the lack of data from China and other major world producers.

# SILICON

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

**Domestic Production and Use:** Estimated value of silicon alloys and metal produced in the United States in 2014 was $1.24 billion. Four companies produced silicon materials in seven plants, all east of the Mississippi River. Ferrosilicon and metallurgical-grade silicon metal were produced in four and five plants, respectively. Two companies produced both products at two plants. 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 and 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:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production: | | | | | |
| Silicon alloys and metal | W | 326 | 383 | 365 | 359 |
| Imports for consumption: | | | | | |
| Ferrosilicon, all grades[1] | 157 | 156 | 173 | 159 | 163 |
| Silicon metal | 171 | 187 | 136 | 118 | 121 |
| Exports: | | | | | |
| Ferrosilicon, all grades[1] | 15 | 20 | 12 | 10 | 9 |
| Silicon metal | 65 | 79 | 75 | 38 | 42 |
| Consumption, apparent: | | | | | |
| Ferrosilicon, all grades[1] | 312 | W | W | W | W |
| Silicon metal[2] | W | W | W | W | W |
| Total | W | 564 | 601 | 599 | 599 |
| Price,[3] average, cents per pound Si: | | | | | |
| Ferrosilicon, 50% Si | 109 | 111 | 100 | 103 | 109 |
| Ferrosilicon, 75% Si | 97.2 | 102 | 91.7 | 94.3 | 98.3 |
| Silicon metal[2] | 140 | 158 | 127 | 122 | 121 |
| Stocks, producer, yearend: | | | | | |
| Silicon alloys and metal | W | 30 | 34 | 29 | 29 |
| Net import reliance[4] as a percentage of apparent consumption: | | | | | |
| Ferrosilicon, all grades[1] | 44 | <50 | <50 | <50 | <45 |
| Silicon metal[2] | <50 | <40 | <25 | <30 | <40 |
| Total | W | 42 | 36 | 39 | 40 |

**Recycling:** Insignificant.

**Import Sources (2010–13):** Ferrosilicon: Russia, 45%; China, 23%; Canada, 12%; Venezuela, 12%; and other, 8%. Silicon metal: Brazil, 36%; South Africa, 21%; Canada, 14%; Australia, 9%; and other, 20%. Total: Russia, 24%; Brazil, 18%; Canada, 14%; Venezuela, 11%; and other, 33%.

| **Tariff:** **Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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. |
| Ferrosilicon manganese | 7202.30.0000 | 3.9% ad val. |

Prepared by **Christopher A. Tuck [Contact Emily K. Schnebele, (703) 648–4945, eschnebele@usgs.gov]**

# 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 2014, expressed in terms of contained silicon, was expected to decrease slightly from that of 2013. Annual average U.S. ferrosilicon spot market prices in 2014 were expected to increase 5.1% for 50%-grade ferrosilicon and 4.3% for 75%-grade ferrosilicon, despite a slight decrease in crude steel production.

Demand for silicon metal comes primarily from the aluminum and chemical industries, with more than 75% of silicon metal typically consumed by the chemical industry. The annual average silicon metal spot market price was expected to decrease by about 8.2% in 2014 from that in 2013.

Moderate increases in silicon materials production capacity occurred worldwide in 2014. Annual production capacity (gross weight) was expected to increase in Iceland by 87,000 tons in 2015; however, global silicon capacity was expected to remain about the same owing to the closing of production facilities in Ukraine. However, world production of silicon materials was expected to decrease in 2014 from that in 2013, owing to less raw steel production throughout the Commonwealth of Independent States, Europe, and North America.

**World Production and Reserves:**

| | Production[e, 5] | | Reserves[6] |
|---|---|---|---|
| | 2013 | 2014 | |
| United States | 365 | 359 | The reserves in most major producing countries are ample in relation to demand. Quantitative estimates are not available. |
| Bhutan[7] | 54 | 54 | |
| Brazil | 230 | 230 | |
| Canada | 60 | 60 | |
| China | 5,200 | 5,000 | |
| France | 130 | 131 | |
| Iceland | 75 | 75 | |
| India[7] | 86 | 86 | |
| Norway | 362 | 369 | |
| Russia | 733 | 699 | |
| South Africa | 84 | 86 | |
| Ukraine[7] | 96 | 89 | |
| Venezuela[7] | 48 | 49 | |
| Other countries | 359 | 389 | |
| World total (rounded) | 7,880 | 7,680 | |

Ferrosilicon accounts for about 95% of world silicon production on a gross-weight basis and 77% on a silicon-content basis. The leading countries for ferrosilicon production were, in descending order and on a gross-weight basis, China, Russia, Norway, the United States, and Ukraine, and for silicon metal production were China, the United States, Norway, Brazil, and France. China was by far the leading producer of ferrosilicon (6,000,000 tons) and silicon metal (1,300,000 tons) in 2014.

**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]Based on U.S. dealer import price.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]Production quantities are combined totals of estimated silicon content for ferrosilicon and silicon metal, as applicable, except as noted.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.
[7]Ferrosilicon only.

# SILVER

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

**Domestic Production and Use:** In 2014, the United States produced approximately 1,170 tons of silver with an estimated value of $718 million. Silver was produced at 3 silver mines and as a byproduct or coproduct from 39 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 indicated production of commercial-grade silver, with an estimated total output of 2,200 tons from domestic and foreign ores and concentrates, and from old and new scrap. The physical properties of silver include high ductility, electrical conductivity, malleability, and reflectivity. In 2014, the estimated uses for silver were electrical and electronics, 42%; coins and medals, 35%; photography, 13%; jewelry and silverware, 7%; and other, 3%. Other applications for silver include use in bandages and pharmaceuticals for wound care, batteries, bearings, brazing and soldering, catalytic converters in automobiles, cell phone covers to reduce the spread of bacteria, clothing to minimize odor, electroplating, inks, mirrors, solar cells, water purification, and wood treatment. An emerging use of silver is in athletic clothing where biosensing silver fibers may be woven directly into the fabric. This athletic clothing transmits biometric data such as the wearer's real-time heartbeat to a sensor that displays the data. Silver metal in fine powder form is also being used in 3D printing to make jewelry and various other items. Silver was used for miniature antennas in radio frequency identification devices that were used in casino chips, toll road transponders, gasoline speed purchase devices, passports, and on packages to keep track of inventory shipments. Mercury and silver, the main components of dental amalgam, are biocides, and their use in amalgam inhibits recurrent decay.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine | 1,280 | 1,120 | 1,060 | 1,040 | 1,170 |
| Refinery: | | | | | |
| Primary | 819 | 790 | 796 | 800 | 800 |
| Secondary (new and old scrap) | 1,330 | 1,710 | 1,660 | 1,700 | 1,400 |
| Imports for consumption[2] | 5,370 | 6,410 | 5,070 | 5,030 | 4,900 |
| Exports[2] | 709 | 904 | 946 | 409 | 300 |
| Consumption, apparent[3] | 7,530 | 7,920 | 5,930 | 6,620 | 6,900 |
| Price average, dollars per troy ounce[4] | 20.20 | 35.26 | 31.21 | 23.80 | 19.03 |
| Stocks, yearend: | | | | | |
| Industry | 123 | 150 | 109 | 110 | 120 |
| Treasury Department[5] | 498 | 498 | 498 | 498 | 498 |
| COMEX | 3,260 | 3,650 | 4,610 | 5,350 | 5,610 |
| Employment, mine and mill,[6] number | 814 | 632 | 709 | 819 | 792 |
| Net import reliance[7] as a percentage of apparent consumption | 65 | 64 | 54 | 59 | 63 |

**Recycling:** In 2014, approximately 1,400 tons of silver was recovered from new and old scrap, about 20% of apparent consumption.

**Import Sources (2010–13):**[2] Mexico, 53%; Canada, 28%; Poland, 6%; Peru, 3%; and other, 10%.

**Tariff:** No duties are imposed on imports of unrefined silver or refined bullion.

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

**Government Stockpile:** None.

**Events, Trends, and Issues:** In October 2014, the silver price averaged $17.16 per troy ounce, 22% lower than the average October 2013 price. The overall decline in silver prices corresponded to a small drop in global industrial consumption owing to slower economic growth, particularly the eurozone, and to substitution and thrifting. Demand for silver by investors continued to increase as they sought safe-haven investments and as the price of silver decreased. On November 7, a group of 16 silver exchange traded funds (ETFs) held about 20,200 tons of silver, slightly higher than the 19,680 tons held at yearend 2013. In November, Thomson Reuters reported that the U.S. Mint had temporarily sold out of silver eagle coins owing to an increase in demand. Demand for coins was expected to increase in the fourth quarter.

Prepared by **Florence C. Katrivanos [(703) 648–6782, fkatrivanos@usgs.gov]**

# SILVER

Global demand for silver in photography continued to decline, and in the United States, demand fell to about 498 tons, compared with a high of about 2,000 tons in 2000. Since 2000, demand for silver in photographic applications has steadily declined owing to increasing popularity of digital cameras. Improvements in the cameras of smartphones and tablets have contributed to the growth in digital photography. Although silver was still used in x-ray films, imaging facilities have been transitioning to digital imaging systems. Demand for silver in jewelry, electronic applications, and other industrial applications declined, while the use of silver in brazing alloys, coins, silverware, and solders increased. The use of trace amounts of silver in bandages and pharmaceuticals for wound care and minor skin infections was also increasing.

World silver mine production increased slightly to 26,100 tons, principally as a result of increased production from mines in Australia, Bolivia, China, and Peru. Domestic silver mine production rose slightly as the Lucky Friday Mine (silver-lead-zinc) in Idaho's Coeur d'Alene mining district continued to ramp up production to levels exceeding preclosure levels. The Lucky Friday Mine was closed at yearend 2011 following an accident and rock burst, and reopened in the first quarter of 2013. The Pinto Valley Mine, a copper mine in Arizona, ceased recovering byproduct silver and the Hollister Mine, a gold-silver mine in Nevada, ceased production.

**World Mine Production and Reserves:** Reserves for Australia and Peru were revised based on new information from Government and industry sources.

| | Mine production | | Reserves[8] |
|---|---|---|---|
| | 2013[e] | 2014[e] | |
| United States | 1,040 | 1,170 | 25,000 |
| Australia | 1,840 | 1,900 | 85,000 |
| Bolivia | 1,290 | 1,300 | 22,000 |
| Canada | 627 | 646 | 7,000 |
| Chile | 1,170 | 1,200 | 77,000 |
| China | 4,100 | 4,200 | 43,000 |
| Mexico | 4,860 | 4,700 | 37,000 |
| Peru | 3,670 | 3,700 | 98,900 |
| Poland | 1,200 | 1,200 | 85,000 |
| Russia | 1,720 | 1,700 | NA |
| Other countries | 4,440 | 4,400 | 50,000 |
| World total (rounded) | 26,000 | 26,100 | 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 future reserves and resources.

**Substitutes:** Digital imaging, film with reduced silver content, silverless black-and-white film, and xerography substitute for silver that has traditionally been used in black-and-white as well as color photographic applications. Surgical pins and plates may be made with 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]Ores and concentrates, refined bullion, and doré; excludes coinage, and waste and scrap material.
[3]Defined as mine production + secondary production + imports – exports + adjustments for Government and industry stock changes.
[4]Handy & Harman quotations.
[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; Greens Creek Mine is included under zinc.
[7]Defined as imports – exports + adjustments for Government and industry stock changes.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.

# 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 2014 was estimated to be about $1.7 billion.[1] U.S. production of 11.6 million tons was slightly higher than in 2013 but about one million tons higher than production in 2010. The U.S. soda ash industry comprised four companies in Wyoming operating five plants, one company in California with one plant, and one company with one mothballed plant in Colorado that owned one of the Wyoming plants. The five producers have a combined annual nameplate capacity of 14.5 million tons. Salt, sodium sulfate, and borax were produced as coproducts of sodium carbonate production in California. Sodium bicarbonate, sodium sulfite, and chemical caustic soda were manufactured as coproducts at several of the Wyoming soda ash plants. Sodium bicarbonate was produced at the Colorado operation using soda ash feedstock shipped from the company's Wyoming facility.

Based on 2014 quarterly reports, the estimated 2014 distribution of soda ash by end use was glass, 47%; chemicals, 30%; soap and detergents, 7%; distributors, 6%; flue gas desulfurization and miscellaneous uses, 4% each; pulp and paper, and water treatment, 1% each.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production[2] | 10,600 | 10,700 | 11,100 | 11,500 | 11,600 |
| Imports for consumption | 20 | 27 | 13 | 13 | 15 |
| Exports | 5,390 | 5,470 | 6,110 | 6,470 | 6,670 |
| Consumption: | | | | | |
| Reported | 5,270 | 5,150 | 5,060 | 5,120 | 5,100 |
| Apparent | 5,200 | 5,220 | 4,980 | 4,990 | 4,970 |
| Price: | | | | | |
| Quoted, yearend, soda ash, dense, bulk: | | | | | |
| F.o.b. Green River, WY, dollars per short ton | 260.00 | 260.00 | 275.00 | 275.00 | 290.00 |
| Average sales value (natural source), | | | | | |
| f.o.b. mine or plant, dollars per short ton | 116.47 | 133.57 | 141.90 | 133.18 | 138.00 |
| Stocks, producer, yearend | 220 | 282 | 338 | 348 | 315 |
| Employment, mine and plant, number | 2,400 | 2,400 | 2,400 | 2,500 | 2,500 |
| Net import reliance[3] 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 (2010–13):** Canada, 22%; Italy, 20%; Turkey, 14%; United Kingdom, 11%; and other, 33%.

| **Tariff:** Item | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| Disodium carbonate | 2836.20.0000 | 1.2% ad val. |

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

**Government Stockpile:** None.

**Events, Trends, and Issues:** Relatively low production costs and more favorable 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 natural soda ash. 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. Cessation of production has been reported in recent years in Australia, Brazil, China, Japan, South Korea, and the United Kingdom. Some production in Kenya was curtailed owing to high production costs, especially fuel costs.

Prepared by **Wallace P. Bolen [(703) 648–7727, wbolen@usgs.gov]**

# SODA ASH

A State-owned corporation in Tanzania continued to seek a partner to develop soda ash facilities at Lake Natron, a salt lake in northern Tanzania and another operation in the Engaruka Basin, south of Lake Natron. The Lake Natron project is controversial because Lake Natron is the breeding ground for approximately one-third of the world's Lesser Flamingos.

In June, one of the major Wyoming soda ash producers announced soda ash price increases effective July 1, 2014, or as contracts permitted. Other producers followed with similar announcements. The increases were necessary to recover production cost increases and assist in continued investments in the operations.

Three groups dominate production and have become the world's leading suppliers of soda ash—ANSAC of the United States (which represented three of the five domestic producers in 2014), multiple producers in China, and Solvay S.A. of Belgium. If the U.S. and world economy improves and export sales increase, U.S. production may be higher in 2014 and 2015. The United States likely will continue to compete with producers in China in the Far East markets. Asia and South America remain the most likely areas for increased soda ash consumption in the near future. Several private sector forecasters suggest that world soda ash production (including natural and synthetic) could approach 65 million tons by 2020.

**World Production and Reserves:**

| | Mine Production | | Reserves[4, 5] |
|---|---|---|---|
| Natural: | 2013 | 2014[e] | |
| United States | 11,500 | 11,600 | [6]23,000,000 |
| Botswana | 235 | 250 | 400,000 |
| Kenya | 500 | 420 | 7,000 |
| Mexico | 290 | 290 | 200,000 |
| Turkey | 1,900 | 2,000 | 200,000 |
| Uganda | NA | NA | 20,000 |
| Other countries | — | — | 260,000 |
| World total, natural (rounded) | 14,400 | 14,600 | 24,000,000 |
| World total, synthetic (rounded) | 36,900 | 37,000 | XX |
| World total (rounded) | 51,300 | 51,600 | 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 that 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 entice 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 environmentally deleterious wastes.

**Substitutes:** Caustic soda can be substituted for soda ash in certain uses, particularly in the pulp and paper, water treatment, and certain chemical sectors. Soda ash, soda liquors, or trona can be used as feedstock to manufacture chemical caustic soda, which is an alternative to electrolytic caustic soda.

[e]Estimated. E Net exporter. NA Not available. XX Not applicable. — Zero.
[1]Does not include values for soda liquors and mine waters.
[2]Natural only.
[3]Defined as imports – exports + adjustments for Government and industry stock changes.
[4]The reported quantities are sodium carbonate only. About 1.8 tons of trona yields 1 ton of sodium carbonate.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]From trona, nahcolite, and dawsonite sources.

# STONE (CRUSHED)[1]

(Data in million metric tons unless otherwise noted)[2]

**Domestic Production and Use:** In 2014, 1.26 billion metric tons of crushed stone valued at more than $12.8 billion was produced by 1,550 companies operating 4,000 quarries, 91 underground mines, and 210 sales/distribution yards in 50 States. Leading States were, in descending order of production, Texas, Pennsylvania, Missouri, Ohio, Florida, Illinois, Kentucky, North Carolina, Georgia, and Virginia, which together accounted for more than one-half of the total crushed stone output. Of the total domestic crushed stone produced in 2014, about 69% was limestone and dolomite; 14%, granite; 7%, traprock; 5%, miscellaneous stone; 4%, sandstone and quartzite; and the remaining 1% was divided, in descending order of tonnage, among marble, volcanic cinder and scoria, slate, shell, and calcareous marl. It is estimated that of the 1.31 billion tons of crushed stone consumed in the United States in 2014, 46% was reported by use, 27% was reported for unspecified uses, and 27% of the total consumed was estimated for nonrespondents to the U.S. Geological Survey (USGS) canvasses. Of the 600 million tons reported by use, 82% was used as construction material, mostly for road construction and maintenance; 10%, for cement manufacturing; 2% each, for lime manufacturing and for agricultural uses; and 4%, for special and miscellaneous uses and products. To provide a more accurate estimate of the consumption patterns for crushed stone, the "unspecified uses—reported and estimated," as defined in the USGS Minerals Yearbook, are not included in the above percentages.

The estimated output of crushed stone in the 48 conterminous States shipped for consumption in the first 9 months of 2014 was 955 million tons, an increase of 8% compared with that of the same period of 2013. Third quarter shipments for consumption increased by 9% compared with those of the same period of 2013. Additional production information, by quarter for each State, geographic division, and the United States, is reported in the USGS quarterly Mineral Industry Surveys for Crushed Stone and Construction Sand and Gravel.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production | 1,160 | 1,150 | 1,170 | 1,180 | 1,260 |
| Recycled material | 26 | 27 | 30 | 35 | 35 |
| Imports for consumption | 15 | 15 | 15 | 18 | 20 |
| Exports | 1 | 1 | 1 | ([3]) | ([3]) |
| Consumption, apparent | 1,200 | 1,200 | 1,220 | 1,230 | 1,310 |
| Price, average value, dollars per metric ton | 9.57 | 9.65 | 9.75 | 9.99 | 10.15 |
| Employment, quarry and mill, number[4] | 67,600 | 67,000 | 66,200 | 65,900 | 66,000 |
| Net import reliance[5] as a percentage of apparent consumption | 1 | 1 | 1 | 1 | 1 |

**Recycling:** Road surfaces made of asphalt and crushed stone and, to a lesser extent, 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. The amount of material reported to be recycled increased slightly in 2014 compared with that of the previous year.

**Import Sources (2010–2013):** Mexico, 67%; The Bahamas, 19%; Canada, 9%; Honduras, 4%; and other, 1%.

| **Tariff: Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| Crushed stone | 2517.10.00 | 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.

Prepared by **Jason Christopher Willett [(703) 648-6473, jwillett@usgs.gov]**

# STONE (CRUSHED)

**Events, Trends, and Issues:** Crushed stone production was about 1.26 billion tons in 2014, an increase of 7% compared with that of 2013. Apparent consumption also increased to about 1.31 billion tons. Demand for crushed stone was higher in 2014 because of increased demand every quarter since the second quarter of 2013, which offset the slowdown in activity that some of the principal construction markets had experienced during the previous years. With this significantly stronger construction activity across the country in 2014, recovery in the private sector and residential construction experiencing a level of growth not seen since late 2005, consumption of construction aggregates is likely to continue to increase. It is expected that the increased consumption in 2014 from that in 2013 will reach or exceed the historical annual average of the past 50 years, which was a 2% to 4% increase per year. The underlying factors that would support a rise in prices of crushed stone are expected to be present in 2014, especially in and near metropolitan areas.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[6] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 1,180 | 1,260 | 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 sand and gravel, iron and steel slag, sintered or expanded clay or shale, and perlite or vermiculite.

[e]Estimated. NA Not available.
[1]See also Stone (Dimension).
[2]See Appendix A for conversion to short tons.
[3]Less than ½ unit.
[4]Including office staff. Source: Mine Safety and Health Administration.
[5]Defined as imports – exports.
[6]See Appendix C for resource/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 country chapters of the USGS Minerals Yearbook.

# STONE (DIMENSION)[1]

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** Approximately 2.25 million tons of dimension stone, valued at $451 million, was sold or used by U.S. producers in 2014. Dimension stone was produced by 208 companies, operating 274 quarries, in 33 States. Leading producer States were, in descending order by tonnage, Texas, Wisconsin, Massachusetts, Indiana, and Georgia. These five States accounted for about 66% of the production and contributed about 60% of the value of domestic production. Approximately 45%, by tonnage, of dimension stone sold or used was limestone, followed by granite (22%), sandstone (16%), miscellaneous stone (14%), marble (2%), and slate (1%). By value, the leading sales or uses were for limestone (39%), followed by granite (29%), miscellaneous stone (13%), sandstone (12%), marble (4%), and slate (3%). Rough stone represented 58% of the tonnage and 46% 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 (50%), and in irregular-shaped stone (33%). Dressed stone mainly was sold for ashlars and partially squared pieces (44%), curbing (21%), and flagging (10%), by tonnage.

| **Salient Statistics—United States:**[2] | **2010** | **2011** | **2012** | **2013** | **2014**[e] |
|---|---|---|---|---|---|
| Sold or used by producers: | | | | | |
| Tonnage | 1,670 | 1,850 | 2,150 | 2,270 | 2,250 |
| Value, million dollars | 323 | 395 | 452 | 458 | 451 |
| Imports for consumption, value, million dollars | 1,500 | 1,590 | 1,740 | 2,100 | 2,200 |
| Exports, value, million dollars | 55 | 66 | 65 | 61 | 61 |
| Consumption, apparent, value, million dollars | 1,770 | 1,910 | 2,130 | 2,500 | 2,590 |
| Price | Variable, depending on type of product | | | | |
| Employment, quarry and mill, number[3] | 3,200 | 3,600 | 3,200 | 4,000 | 4,700 |
| Net import reliance[4] as a percentage of apparent consumption (based on value) | 82 | 80 | 79 | 82 | 83 |
| Granite only: | | | | | |
| Production | 699 | 462 | 499 | 498 | 500 |
| Exports (rough and finished) | 96 | 80 | 77 | 85 | 85 |
| Price | Variable, depending on type of product | | | | |
| Employment, quarry and mill, number[3] | 2,000 | 1,300 | 700 | 880 | 1,000 |

**Recycling:** Small amounts of dimension stone were recycled, principally by restorers of old stone work.

**Import Sources (2010–13 by value):** All dimension stone: China, 26%; Brazil, 26%; Italy, 23%; Turkey, 16%; and other, 9%. Granite only: Brazil, 45%; China, 23%; India, 14%; Italy, 12%; and other, 6%.

**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 2014. 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.

Prepared by **Thomas P. Dolley [(703) 648–7710, tdolley@usgs.gov]**

# STONE (DIMENSION)

**Events, Trends, and Issues:** The United States is the world's leading market for dimension stone. Imports of dimension stone increased in value to about $2.2 billion compared with $2.1 billion in 2013. Slow growth in the U.S. economy coupled with decreases in new residential construction starts of smaller houses, particularly in the midwestern and northeastern United States, resulted in a slight decrease in domestic production of dimension stone. Dimension stone for construction and refurbishment was used in commercial and residential markets; in 2014, refurbishment and remodeling activity of existing homes increased compared with those of 2013. These factors contributed to a steady rise in dimension stone imports. Dimension stone exports remained static at about $61 million. Apparent consumption, by value, was estimated to be $2.59 billion in 2014—a $93 million increase from that of 2013.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 2,270 | 2,250 | Adequate except for certain special types and local shortages. |
| Other countries | NA | NA | |
| World total | NA | NA | |

**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 Puerto Rico.
[3]Excluding office staff.
[4]Defined as imports – exports.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.

# STRONTIUM

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

**Domestic Production and Use:** Although deposits of strontium minerals occur widely throughout the United States, strontium minerals have not been mined in the United States since 1959. Domestic production of strontium carbonate, the principal strontium compound, ceased in 2006. A few domestic companies produce small quantities of downstream strontium chemicals from imported strontium carbonate. Estimates for end uses of strontium compounds in the United States were pyrotechnics and signals, 30%; ceramic ferrite magnets, 30%; master alloys, 10%; pigments and fillers, 10%; electrolytic production of zinc, 10%; and other applications, including glass, 10%.
It is thought that virtually all of the strontium minerals consumed in the United States since 2006 was used in drilling fluids for oil and natural gas wells.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production | — | — | — | — | — |
| Imports for consumption: | | | | | |
| Strontium minerals | 2,370 | 7,320 | 8,660 | 21,900 | 25,000 |
| Strontium compounds | 8,640 | 10,000 | 8,150 | 7,190 | 7,700 |
| Exports, compounds | 72 | 18 | 71 | 37 | 84 |
| Consumption, apparent, minerals and compounds | 10,900 | 17,300 | 16,700 | 29,000 | 33,000 |
| Price, average value of mineral imports at port of exportation, dollars per ton | 45 | 46 | 50 | 50 | 50 |
| Net import reliance[2] as a percentage of apparent consumption | 100 | 100 | 100 | 100 | 100 |

**Recycling:** None.

**Import Sources (2010–13):** Strontium minerals: Mexico, 100%. Strontium compounds: Mexico, 83%; Germany, 11%; China, 5%; and other, 1%. Total imports: Mexico, 89%; Germany, 7%; China, 3%; and other, 1%.

| **Tariff:** Item | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| Celestite | 2530.90.8010 | Free. |
| Strontium metal | 2805.19.1000 | 3.7% ad val. |
| Compounds: | | |
| 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.

Prepared by **Joyce A. Ober [(703) 648–7717, jober@usgs.gov]**

# STRONTIUM

**Events, Trends, and Issues:** Imports of celestite, the most commonly used strontium mineral, have increased every year since 2010, with virtually all of the material coming from Mexico. Celestite is typically used as the raw material for the production of strontium compounds; however, these imports are thought to be used in drilling fluids for oil and natural gas exploration and production. As such, celestite is ground, but undergoes no chemical processing.

Consumption of strontium compounds was thought to be approximately equal in the production of ceramic ferrite magnets and pyrotechnics and signals. 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. 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 expected improvements to global economic conditions, consumption of strontium compounds is expected to increase. Little information is available about the potential for celestite consumption in drilling fluids, but if oil and gas drilling continues to increase, celestite consumption may increase as well.

In descending order of production, Spain, China, and Mexico are the world's leading producers of celestite. China also is a major importer of celestite.

**World Mine Production and Reserves:**[3]

| | Mine production | | Reserves[4] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | — | — |
| Argentina | 5,000 | 5,000 | All other: |
| China | 120,000 | 100,000 | 6,800,000 |
| Mexico | 40,000 | 45,000 | |
| Morocco | 2,500 | 2,500 | |
| Spain | 165,000 | 165,000 | |
| World total (rounded) | 333,000 | 318,000 | 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 the drilling mud market, barite is the preferred material, but celestite may substitute for barite, especially when barite prices are high.

[e]Estimated. — Zero.
[1]The strontium content of celestite is 43.88%; this factor was used to convert units of celestite to strontium content.
[2]Defined as imports – exports.
[3]Gross weight of strontium minerals in metric tons.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.

# SULFUR

(Data in thousand metric tons of sulfur unless otherwise noted)

**Domestic Production and Use:** In 2014, recovered elemental sulfur and byproduct sulfuric acid were produced at 103 operations in 27 States. Total shipments were valued at about $927 million. Elemental sulfur production was 9.0 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 39 companies at 96 plants in 26 States. Byproduct sulfuric acid, representing about 7% of production of sulfur in all forms, was recovered at seven nonferrous smelters in five States by five companies. Domestic elemental sulfur provided 63% of domestic consumption, and byproduct acid accounted for about 6%. The remaining 31% 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:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production | | | | | |
| Recovered elemental | 8,320 | 8,230 | 8,410 | 8,600 | 9,040 |
| Other forms | 791 | 720 | 586 | 616 | 730 |
| Total (rounded) | 9,110 | 8,950 | 9,000 | 9,210 | 9,770 |
| Shipments, all forms | 9,170 | 8,930 | 9,030 | 9,200 | 9,760 |
| Imports for consumption: | | | | | |
| Recovered, elemental[e] | 2,950 | 3,270 | 2,930 | 2,990 | 2,400 |
| Sulfuric acid, sulfur content | 690 | 872 | 933 | 972 | 1,030 |
| Exports: | | | | | |
| Recovered, elemental | 1,450 | 1,310 | 1,850 | 1,750 | 2,100 |
| Sulfuric acid, sulfur content | 71 | 109 | 53 | 54 | 50 |
| Consumption, apparent, all forms | 11,300 | 11,700 | 11,000 | 11,400 | 11,000 |
| Price, reported average value, dollars per ton of elemental sulfur, f.o.b., mine and (or) plant | 70.16 | 159.88 | 123.54 | 68.83 | 95.00 |
| Stocks, producer, yearend | 166 | 175 | 132 | 161 | 175 |
| Employment, mine and (or) plant, number | 2,600 | 2,600 | 2,600 | 2,600 | 2,500 |
| Net import reliance[1] as a percentage of apparent consumption | 19 | 23 | 18 | 19 | 11 |

**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 (2010–13):** Elemental: Canada, 81%; Mexico, 12%; Venezuela, 3%; and other, 4%. Sulfuric acid: Canada, 66%; Mexico, 16%; and other, 18%. Total sulfur imports: Canada, 78%; Mexico, 13%; Venezuela, 2%; and other, 7%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Sulfur, crude or unrefined | 2503.00.0010 | Free. |
| Sulfur, all kinds, other | 2503.00.0090 | Free. |
| Sulfur, sublimed or precipitated | 2802.00.0000 | Free. |
| Sulfuric acid | 2807.00.0000 | Free. |

**Depletion Allowance:** 22% (Domestic and foreign).

**Government Stockpile:** None.

**Events, Trends, and Issues:** Total U.S. sulfur production and shipments increased by about 6% compared with those of 2013. Domestic production of elemental sulfur from petroleum refineries and recovery from natural gas operations increased by 5%. Domestically, refinery sulfur production is expected to continue to increase a result of processing more Canadian bituminous crude, sulfur from natural gas processing is expected to remain stable, and byproduct sulfuric acid is expected to remain relatively stable, unless one or more of the remaining nonferrous smelters close.

Prepared by **Lori E. Apodaca [(703) 648–7724, lapodaca@usgs.gov]**

# SULFUR

World sulfur production increased slightly and is likely to steadily increase for the foreseeable future. Significantly increased production is expected from sulfur recovery at liquefied natural gas operations in the Middle East and expanded oil sands operations in Canada, unless a downturn in the world economy limits investments in those areas.

The contract sulfur prices in Tampa, FL, began 2014 at around $75 per ton. The price increased to $136 per ton at the end of July and remained at that level through late–October when prices decreased to $129 per ton. Export prices were higher than domestic prices. In the past few years, sulfur prices have been variable a result in the volatility of the demand for sulfur. The price increase seen in 2014 is reflected in China's demand for sulfur.

Domestic phosphate rock consumption was slightly lower in 2014 than in 2013, which resulted in decreased demand for sulfur to process the phosphate rock into phosphate fertilizers.

**World Production and Reserves**:

| | Production—All forms | |
|---|---|---|
| | 2013 | 2014[e] |
| United States | 9,210 | 9,770 |
| Australia | 860 | 900 |
| Brazil | 545 | 550 |
| Canada | 6,370 | 6,000 |
| Chile | 1,700 | 1,700 |
| China | 10,500 | 12,000 |
| Finland | 740 | 740 |
| France | 650 | 650 |
| Germany | 3,880 | 3,900 |
| India | 2,430 | 2,430 |
| Iran | 1,890 | 1,900 |
| Italy | 740 | 740 |
| Japan | 3,300 | 3,300 |
| Kazakhstan | 2,850 | 2,850 |
| Korea, Republic of | 1,300 | 1,300 |
| Kuwait | 820 | 820 |
| Mexico | 1,810 | 1,810 |
| Netherlands | 515 | 515 |
| Poland | 1,080 | 1,100 |
| Qatar | 850 | 850 |
| Russia | 7,250 | 7,300 |
| Saudi Arabia | 3,900 | 4,000 |
| South Africa | 270 | 290 |
| Spain | 270 | 270 |
| United Arab Emirates | 2,000 | 2,000 |
| Uzbekistan | 560 | 560 |
| Venezuela | 800 | 800 |
| Other countries | 3,360 | 3,360 |
| World total (rounded) | 70,400 | 72,400 |

**Reserves[2]**

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, but low-cost methods have not been developed to recover sulfur from these sources. 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 imports – exports + adjustments for Government and industry stock changes.
[2]See Appendix C for resource/reserve definitions and information concerning data sources.

# TALC AND PYROPHYLLITE[1]

(Data in thousand metric tons unless otherwise noted)

**Domestic Production and Use:** Domestic talc production in 2014 was estimated to be 535,000 tons valued at $21 million. Four companies operated six talc-producing mines in four States in 2014. The top three companies accounted for more than 99% of the U.S. talc production. One company in California shipped from stocks. Montana was the leading producer State, followed by Texas, Vermont, and Virginia. Sales of talc were estimated to be 554,000 tons valued at $90 million. Talc produced and sold in the United States was used for ceramics, 26%; paper, 21%; paint, 19%; roofing, 9%; plastics, 8%; rubber, 4%; cosmetics, 3%; and other, 10%. About 260,000 tons of talc was imported; more than 75% of the imported talc was used in cosmetics, paint, and plastic markets. The end use ranking in the United States, when including imported talc and in decreasing order by tonnage, was plastics, ceramics, paint, paper, roofing, cosmetics, rubber, and other. One company in North Carolina mined pyrophyllite. Production of pyrophyllite increased from that of 2013 and consumption was, in decreasing order by tonnage, in refractory products, ceramics, and paint.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production, mine | 604 | 616 | 515 | 542 | 535 |
| Sold by producers | 567 | 567 | 575 | 560 | 554 |
| Imports for consumption | 242 | 285 | 350 | 269 | 260 |
| Exports | 240 | 223 | 270 | 189 | 190 |
| Shipments from Government stockpile excesses | — | — | — | — | — |
| Consumption, apparent | 606 | 678 | 595 | 622 | 605 |
| Price, average, processed, dollars per metric ton | 150 | 155 | 152 | 163 | 163 |
| Employment, mine and mill | 280 | 290 | 310 | 280 | 250 |
| Net import reliance[2] as a percentage of apparent consumption | 1 | 9 | 13 | 13 | 12 |

**Recycling:** Insignificant.

**Import Sources (2010–13):** China, 30%; Canada, 29%; Pakistan, 23%; and other, 18%.

| **Tariff:** **Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| Not crushed, not powdered | 2526.10.0000 | Free. |
| Crushed or powdered | 2526.20.0000 | Free. |
| Cut or sawed | 6815.99.2000 | Free. |

**Depletion Allowance:** Block steatite talc: 22% (Domestic), 14% (Foreign). Other: 14% (Domestic and foreign).

**Government Stockpile:**

**Stockpile Status—9–30–14[3]**
**(Metric tons)**

| **Material** | **Inventory** | **Disposal Plan FY 2014** | **Disposals FY 2014** |
|---|---|---|---|
| Talc, block and lump | 480 | [4]907 | [4]876 |
| Talc, ground | 132 | — | — |

Prepared by **Robert L. Virta [(703) 648–7726, rvirta@usgs.gov]**

# TALC AND PYROPHYLLITE

**Events, Trends, and Issues:** Since 1994, talc production and apparent consumption decreased by 44% and 34%, respectively. The decline can be attributed to many factors. Ceramic tile and sanitaryware formulations and the technology for firing ceramic tile changed during that time, reducing the amount of talc required for the manufacture of some ceramic products. Also, because ceramic tile imports increased, many domestic ceramic-tile manufacturing plants were closed, and a major domestic talc supplier to the ceramic tile industry ceased operations in 2009. For paint, the industry shifted more of its production to water-based paint from oil-based paint to reduce volatile emissions. That reduced the use of talc, which repels water. For cosmetics, manufacturers of body dusting powders shifted some of their production from talc-based to corn starch-based products. Paper manufacturing decreased from the 1990s and use of chemical pitch control agents increased, reducing the demand for talc for pitch control. Other markets remained relatively constant during the 20-year period. Talc use in plastics, particularly automotive plastic components, increased, but a significant share of the increase in demand appears to have been met through the use of imported talc.

Domestic talc production and sales decreased slightly in 2014. U.S. exports increased slightly from those of 2013, with Canada and Mexico receiving more than 70% of U.S. talc exports. U.S. imports decreased slightly from those of 2013. In 2014, Canada and China remained the lead suppliers of talc to the United States, accounting for 37% and 40% of U.S. talc imports, respectively.

The Board of Governors of the Federal Reserve System reported a 5.6% increase in manufacturing of durable goods, including an 8.1% growth in automobile and truck manufacture and a 7.7% growth in plastics and rubber components from August 2013 to August 2014. The U.S. Census Bureau reported that housing starts increased by 8% between August 2013 and August 2014. These trends could lead to increased consumption of talc, if they are sustained, because talc is used in manufacturing catalytic converter bodies (ceramics), automotive and truck body and underhood components (plastics), paint and coatings (fillers and extenders), and plastics and rubber (fillers and extenders in plastic products, tires, and other rubber components). Talc is used to manufacture such construction products as adhesives, caulks, ceramics, joint compounds, paint, and roofing.

Sales of pyrophyllite increased in 2014. Sales to industries that use pyrophyllite to manufacture ceramics and paints increased slightly in 2014 owing to the continued recovery of those sectors of the economy.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[5] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 542 | 535 | 140,000 |
| Brazil[6] | 550 | 500 | 45,000 |
| China | 2,200 | 2,200 | Large |
| Finland | 440 | 360 | Large |
| France | 420 | 420 | Large |
| India[6] | 663 | 660 | 75,000 |
| Japan[6] | 376 | 380 | 100,000 |
| Korea, Republic of[6] | 520 | 540 | 11,000 |
| Other countries[6] | 1,190 | 1,350 | Large |
| World total (rounded)[6] | 6,900 | 6,950 | 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, 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. — Zero.
[1]Excludes pyrophyllite, unless noted.
[2]Defined as imports – exports + adjustments for Government stock changes.
[3]See Appendix B for definitions.
[4]Included talc, block and lump, and talc, ground.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]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 mineralogically complex, and most are not commercially recoverable. Companies in the United States produced tantalum alloys, compounds, and metal from imported tantalum-containing materials, and metal and alloys were recovered from foreign and domestic scrap. Tantalum was consumed mostly in the form of alloys, compounds, fabricated forms, ingot, and metal powder. Tantalum capacitors were estimated to account for more than 60% of tantalum use, internationally. Major end uses for tantalum capacitors include automotive electronics, personal computers, and celular telephones. The value of tantalum consumed in 2014 was expected to exceed $250 million as measured by the value of imports.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine | — | — | — | — | — |
| Secondary | NA | NA | NA | NA | NA |
| Imports for consumption[e, 1] | 1,600 | 1,850 | 1,010 | 1,100 | 921 |
| Exports[e, 1] | 438 | 648 | 577 | 844 | 782 |
| Government stockpile releases[e, 2] | — | — | — | — | — |
| Consumption, apparent | 1,160 | 1,210 | 437 | 260 | 139 |
| Price, tantalite, dollars per pound of $Ta_2O_5$ content[3] | 54 | 125 | 108 | 118 | 110 |
| Net import reliance[4] 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 (2010–13):** Tantalum minerals: Brazil, 31%; Canada, 19%; Australia, 12%; and other, 38%. Tantalum metal: China, 28%; Kazakhstan, 27%; Thailand, 14%; Germany, 13%; and other, 18%. Tantalum waste and scrap: Estonia, 20%; Russia, 13%; China, 12%; and other 55%. Tantalum contained in niobium (columbium) and tantalum ore and concentrate; tantalum metal; and tantalum waste and scrap: China, 21%; Germany, 12%; Kazakhstan, 10%; Russia, 7%; and other, 50%.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Synthetic tantalum-niobium concentrates | 2615.90.3000 | Free. |
| Tantalum ores and concentrates | 2615.90.6060 | Free. |
| Tantalum oxide[5] | 2825.90.9000 | 3.7% ad val. |
| Potassium fluorotantalate[5] | 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:**

**Stockpile Status—9–30–14[6]**

| Material | Inventory | Disposal Plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|
| Tantalum carbide powder | 1.71 | — | — |
| Tantalum metal scrap | 0.09 | — | — |

Prepared by **John F. Papp [(703) 648–4963, jpapp@usgs.gov]**

# TANTALUM

**Events, Trends, and Issues:** U.S. tantalum apparent consumption in 2014 was estimated to have decreased to about 53% of that of 2013. Tantalum waste and scrap was the leading imported tantalum material, accounting for about 48% of tantalum imports. In 2014, the average price per month of tantalum ore fell from about $116.5 in January to about $92.5 in August. Tantalum is one of the minerals covered by the Dodd-Frank Act. As a result, companies listed by the Securities and Exchange Commission (SEC) were obligated to file a special document form with the SEC describing their source(s) of tantalum from conflict areas or to perform due diligence to make such a determination. Congo (Kinshasa) accounts for about 21% of tantalum world production; the Congo geographic area (Burundi, Congo, and Rwanda), about 53%. Three tantalum mining companies have stopped production since the 2008/2009 world economic slowdown; Morropino (Mozambique), Tanco (Canada), and Wodgina (Australia). In addition, Kenticha (Ethiopia) suspended production while renovating and expanding its operation. Before the economic slowdown, the price of tantalite was $30 to $40 per pound of $Ta_2O_5$ content; since them, the price has risen to $110 to $120 per pound. Since 2008/2009, world tantalum mine production has actually declined while prices increased; suggesting that increased production to meet higher market demand is coming from undocumented sources or that stocks are being drawn down. Tantalum use has been estimated at more than 50% for electronics applications of which capacitors are the leading end use. Tantalum oxide is used in glass lenses to get lighter weight lenses that produce a brighter image. Tantalum carbide is used in cutting tools.

**World Mine Production and Reserves:**

| | Mine production[7] | | Reserves[8] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | — | — |
| Australia | — | — | [9]67,000 |
| Brazil | 98 | 98 | 36,000 |
| Burundi | 20 | 14 | NA |
| Canada | 5 | — | NA |
| China | 60 | 60 | NA |
| Congo (Kinshasa) | *200 | *200 | NA |
| Ethiopia | 8 | 40 | NA |
| Mozambique | 115 | 85 | NA |
| Nigeria | 60 | 60 | NA |
| Rwanda | *600 | *600 | NA |
| World total (rounded) | *1,170 | *1,200 | >100,000 |

**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, all of which are considered uneconomic at 2014 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.
[2]Government stockpile inventory reported by DLA Strategic Materials is the basis for estimating Government stockpile releases.
[3]Price is annual average price reported in Ryan's Notes.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]This category includes other than tantalum-containing material.
[6]See Appendix B for definitions.
[7]Excludes production of tantalum contained in tin slags. Number represents tantalum in ore only; does not include alloys, powder, waste, scrap, or other tantalum articles.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.
[9]For Australia, Joint Ore Reserves Committee (JORC)-compliant reserves were 29,000 tons.
*Revisions based on new data posted on May 14, 2015.

# TELLURIUM

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

**Domestic Production and Use:** In 2014, one firm in Texas produced commercial-grade tellurium from domestic copper anode slimes and lead refinery skimmings. Primary and intermediate producers further refined domestic and imported commercial-grade metal and tellurium dioxide, producing high-purity tellurium and tellurium compounds for specialty applications.

Tellurium was used in the production of cadmium-tellurium-based 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 devices and as a pigment to produce various colors in glass and ceramics.

Global consumption estimates for the end use of tellurium are as follows: 40% solar, 30% thermo electric production, 15% metallurgy, 5% rubber applications, and 10% other.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, refinery | W | W | W | W | W |
| Imports for consumption, unwrought, waste and scrap | 42 | 71 | 36 | 64 | 68 |
| Exports | 59 | 39 | 47 | 42 | 44 |
| Consumption, apparent | W | W | W | W | W |
| Price, dollars per kilogram, 99.95% minimum[1] | 221 | 349 | 150 | 112 | 117 |
| Stocks, producer, refined, yearend | W | W | W | W | W |
| Net import reliance[2] as a percentage of apparent consumption | >60% | <50% | >60% | >80% | >80% |

**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 cadmium-tellurium-based solar cells; however, most of this was new scrap because cadmium-tellurium-based solar cells were relatively new and had not reached the end of their useful life.

**Import Sources (2010–13):** Canada, 46%; China, 17%; Philippines, 13%; Belgium, 10%; and other, 14%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Tellurium | 2804.50.0020 | Free. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **C. Schuyler Anderson [(703) 648–4985, csanderson@usgs.gov]**

# TELLURIUM

**Events, Trends, and Issues:** In 2014, estimated domestic tellurium production was less than production in 2013, due to anode slimes, previously processed domestically, being shipped to Mexico for treatment and refining. Although detailed information on the world tellurium market was not available, world tellurium consumption was estimated to have increased in 2014. The price of tellurium continued to exhibit a seasonal price fluctuation during 2014, with the peak price occurring in the summer months due to China's increased demand for thermoelectrics. Canada remained the leading source of US imports of tellurium, nearly tripling their exports to the United States, and outpacing the next largest supplier (Belgium), by nearly 20 times. China, a historically large supplier of tellurium to the United States, supplied less than one percent of the tellurium consumed to the United States. Although not a major domestic use, in China, tellurium is used with bismuth in thermoelectric cooling devices, such as refrigerators and water dispensers because of increased energy efficiency.

In solar cells, tellurium is mostly used in Cadmium Telluride (CdTe) thin film technologies. In 2013, thin film solar cells constituted about 9% of photovoltaic (PV) module shipments, down significantly from 2012, and CdTe PV module production declined, accounting for 1.4% of the total world PV module production.

A leading producer of high-purity tellurium metals and dioxides in the Philippines shut down their tellurium production, ending 25 years of tellurium production. China's Fanya minor metals exchange began trading tellurium in 2014. By October, 135 metric tons (t) of tellurium were held in Fanya warehouses, which have a total capacity of 1,000(t).

**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.

| | Refinery production | | Reserves[3] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | W | W | 3,500 |
| Canada | 12 | 10 | 800 |
| Japan | 48 | 45 | — |
| Peru | — | — | 3,600 |
| Russia | 35 | 40 | NA |
| Other countries[4] | NA | NA | 16,000 |
| World total (rounded) | NA | NA | 24,000 |

**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. In copper production, tellurium was recovered only during electrolytic refining of smelted copper. Other potential sources of tellurium include bismuth telluride, gold telluride, and lead-zinc ores.

**Substitutes:** Several materials can replace tellurium in most of its uses, but usually with losses in production 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 electrically 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 to CdTe in thin-film PV power cells.

[e]Estimated. NA Not available. W Withheld to avoid disclosing company proprietary data. — Zero.
[1]Average price published by Metal-Pages for 99.95% tellurium.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]See Appendix C for resource/reserve definitions and information concerning data sources.
[4]In addition to the countries listed, Australia, Belgium, Chile, China, Colombia, Germany, India, Kazakhstan, Mexico, the Philippines, Poland, and Sweden produce refined tellurium, but output was not reported, and available information was inadequate for formulation of reliable production and detailed reserve estimates.

# THALLIUM

(Data in kilograms of thallium content 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 $972,000. 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 (HTS) 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 as an alloying component with mercury for low-temperature measurements. Other uses included 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 sink-float separation of minerals.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production, refinery | — | — | — | — | — |
| Imports for consumption:[1] | | | | | |
| Unwrought and powders | 2,000 | 1,300 | — | — | 50 |
| Other | 200 | 200 | 685 | 209 | 150 |
| Total | 2,200 | 1,500 | 685 | 209 | 200 |
| Exports:[1] | | | | | |
| Unwrought and powders | 45 | 34 | 21 | 3 | — |
| Waste and scrap | 55 | 42 | 26 | 11 | 5 |
| Other | 835 | 469 | 31 | 8 | 60 |
| Total | 935 | 545 | 78 | 22 | 65 |
| Consumption[e] | 1,270 | 955 | 607 | 187 | 135 |
| Price, metal, dollars per kilogram[2] | 5,930 | 6,000 | 6,800 | 6,990 | 7,200 |
| Net import reliance[3] as a percentage of estimated consumption | 100 | 100 | 100 | 100 | 100 |

**Recycling:** None.

**Import Sources (2010–13):** Germany, 73%; Russia, 26%; and other, 1%.

| **Tariff:** Item | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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 2014, the price for thallium metal continued to increase for the fifth consecutive year as global supply continued to be relatively constrained. Price increases for thallium in recent years were attributed to the limited availability of thallium produced in China. In 2014, China maintained its policy of eliminating toll-trading tax benefits on exports of thallium that began in 2006, thus contributing to reduced supply conditions on the world market. In July 2010, China canceled a 5% value-added-tax rebate on exports of many minor metals, including fabricated thallium products. Higher internal demand for many metals has prompted China to begin importing greater quantities of thallium.

U.S. imports decreased by 91% during the last 5 years and estimated consumption declined by 89% during that time period. 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 been attributed to an increase in thallium consumption during that time period.

Prepared by **David E. Guberman [(703) 648–4977, dguberman@usgs.gov]**

# THALLIUM

In late 2011, a Brazilian minerals exploration company discovered a substantial thallium deposit in northwest Bahia, Brazil. According to the company, the deposit was unique because it was the only known occurrence in the world in which thallium had been found with cobalt and manganese. In 2014, the company continued exploration activities and investigated partnerships with other firms to help finance the project. Exploration of the site was expected to conclude by yearend 2015. The company had tested a hydrometallurgical process that could be used to extract thallium from manganese ore. The potential construction of a production plant to produce thallium was dependent on obtaining licenses for operation and finding investment partners.

Two of the leading global markets of thallium were the producers of glass lenses, prisms, and windows for the fiber optics and digital camera industries, and the majority of these producers were in China, Japan, and the Republic of Korea.

In 2014, researchers at Brigham Young University successfully converted natural gas into liquid alcohol using lead and thallium. The conversion took place at a temperature that is lower than that used in current industry practices, owing to the relatively low melting points of lead and thallium. The development had the potential to benefit the growing natural gas industry because the process is cheaper and simpler than current conversion methods. The liquid alcohol produced can be used as fuel, potentially reducing dependence on petroleum.

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 EPA has set an enforceable Maximum Contaminant Level for thallium at 2 parts per billion.

**World Refinery Production and Reserves:** There are only a few countries where thallium is obtained commercially as a byproduct in the roasting of copper, lead, and zinc ores or is collected from flue dust. Because most producers withhold thallium production data, estimating global production is challenging. In 2014, global production of thallium was estimated to be less than 10,000 kilograms. China, Kazakhstan, and Russia were believed to be leading producers of primary thallium. Since 2005, substantial thallium-rich deposits have been identified in China, Macedonia, and Russia.

**World Resources:** Although the metal is reasonably abundant in the Earth's crust at a concentration estimated to be 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 forms. 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 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. An additional 630 million kilograms is in world coal resources.

**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 sink-float separation of minerals.

[e]Estimated. — Zero.

[1]Thallium content was estimated by the U.S. Geological Survey.

[2]Estimated price of 99.99%-pure granules or rods in 100- to 250-gram or larger lots.

[3]Defined as imports – exports + adjustments for Government and industry stock changes. Consumption and exports of unwrought thallium were from imported material or from a drawdown in unreported inventories.

# 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. Monazite itself may be recovered as a byproduct of processing heavy-mineral sands for titanium and zirconium minerals. In 2014, monazite was not recovered domestically as a salable product. Essentially all thorium compounds and alloys consumed by the domestic industry were derived from imports. Less than ten companies processed or fabricated various forms of thorium for uses such as catalysts, high-temperature ceramics, and welding electrodes. Thorium's use in most products has generally decreased because of concerns over its naturally occurring radioactivity.

Imports of 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 2014 was $302,000.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, mineral concentrate refinery[1] | — | — | — | — | — |
| Imports for consumption: | | | | | |
| Thorium ore and concentrates (monazite), gross weight | — | 30 | 43 | — | — |
| Thorium compounds (oxide, nitrate, etc.), gross weight[2] | 3.03 | 5.71 | 4.40 | 2.83 | 4.00 |
| Thorium compounds (oxide, nitrate, etc.), $ThO_2$ content[2, e] | 2.24 | 4.22 | 3.26 | 2.09 | 3.00 |
| Exports: | | | | | |
| Thorium ore and concentrates (monazite), gross weight | 1 | — | — | — | — |
| Thorium compounds (oxide, nitrate, etc.), gross weight[2] | 1.50 | 4.28 | 3.16 | 1.01 | 3.50 |
| Thorium compounds (oxide, nitrate, etc.), $ThO_2$ content[2, e] | 1.11 | 3.17 | 2.34 | 0.74 | 2.60 |
| Consumption, apparent[2] | 1.13 | 1.05 | 0.92 | 1.35 | 0.40 |
| Price, thorium compounds, gross weight, dollars per kilogram:[3] | | | | | |
| France | 131 | 158 | 153 | NA | NA |
| India | 58 | 58 | 60 | 65 | 75 |
| Net import reliance[4] as a percentage of apparent consumption[1] | 100 | 100 | 100 | 100 | 100 |

**Recycling:** None.

**Import Sources (2010–13):** Monazite: United Kingdom, 100%. Thorium compounds: India, 92%; and France, 8%. U.S. imports of monazite from the United Kingdom were from previously stockpiled imports.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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 has exhibited a long-term declining trend. Domestic mine production of thorium-bearing monazite ceased at the end of 1994 as world demand for ores containing naturally occurring radioactive thorium declined. Imports and existing stocks supplied essentially all thorium consumed in the United States in 2014.

On the basis of data through September 2014, the average value of imported thorium compounds increased to $75 per kilogram from the 2013 average of $65 per kilogram (gross weight). The increase was primarily caused by a small quantity of high-unit-value imports from the United Kingdom valued at $3,830 per kilogram. The average value of exported thorium compounds decreased to $482 per kilogram based on data through September 2014, compared with $520 per kilogram for all of 2013. The change was attributed to variations in the type and purity of compounds exported in each year.

Prepared by **Joseph Gambogi [(703) 648–7718, jgambogi@usgs.gov]**

# THORIUM

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. Issues associated with thorium's natural radioactivity represented a significant cost to those companies involved in its mining, processing, manufacture, transport, and use.

Interest in thorium as an energy source continued worldwide, as various countries continued research and development of thorium-fueled nuclear power as an alternative to uranium. The Chinese Academy of Sciences continued a research initiative to develop thorium molten-salt reactor technologies. India continued research and development of thorium-related reactor technologies. According to India's Atomic Energy Commission, the process of selection of a site for construction of an advanced heavy-water reactor (AHWR) is in an advanced stage. The AHWR is a nuclear reactor that burns thorium in its fuel core. In Norway, a testing program backed by an international consortium of utilities, industry, and research organizations was planning to demonstrate that thorium-mixed oxide fuel could operate safely in a commercial reactor.

In 2014, exploration and development of rare-earth projects associated with thorium were underway in Australia, Brazil, Canada, Greenland, India, Russia, South Africa, the United States, and Vietnam.

**World Refinery Production and Reserves:**[5] Production and reserves are associated with the recovery of monazite in heavy-mineral sands deposits. Without demand for the rare earths, monazite would probably not be recovered for its thorium content. In 2014, in descending order, India, Malaysia, Vietnam, and Brazil led global production of monazite. Other ore minerals with higher thorium contents, such as thorite, would be available if demand significantly increased.

**World Resources:**[5] The world's leading thorium resources are found in placer, carbonatite, and vein-type deposits. According to a 2014 report by the Organization for Economic Co-operation and Development and International Atomic Energy, worldwide thorium resources from major deposit types are estimated to total more than 6 million tons of thorium.

Thorium resources are found throughout the world and are led by India, Brazil, and Australia. India's Department of Atomic Energy estimated 12 million tons of monazite were contained in heavy-mineral sands. India's monazite was reported to have an average thorium oxide content of 9–10%. Geoscience Australia estimated its resources of thorium at about 0.6 million tons of thorium. Most of the known 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.

[e]Estimated. NA Not available. — Zero.
[1]All domestically consumed thorium was derived from imported materials.
[2]Apparent consumption calculation excludes ore and concentrates.
[3]Based on U.S. Census Bureau customs value.
[4]Defined as imports – exports + adjustments for Government and industry stock changes.
[5]See Appendix C for resource/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 2014. The major uses for tin were cans and containers, 23%; construction, 18%; transportation, 17%; electrical, 12%; and other, 30%. Based on the average Platts Metals Week New York Dealer price for tin, the value of imported refined tin was $830 million, and the value of old scrap recovered domestically was $310 million.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, secondary: | | | | | |
| Old scrap[e] | 11,100 | 11,000 | 11,200 | 11,100 | 11,200 |
| New scrap | 2,680 | 2,530 | 2,440 | 2,700 | 2,800 |
| Imports for consumption, refined tin | 35,300 | 34,200 | 36,900 | 34,900 | 37,300 |
| Exports, refined tin and tin alloys | 5,630 | 5,450 | 5,560 | 5,870 | 5,800 |
| Shipments from Government stockpile | — | — | — | — | — |
| Consumption, reported: | | | | | |
| Primary | 25,300 | 25,200 | 24,500 | 26,500 | 23,300 |
| Secondary | 4,820 | 3,280 | 3,240 | 3,260 | 2,800 |
| Consumption, apparent[1] | 41,400 | 40,300 | 42,300 | 39,900 | 42,300 |
| Price, average, cents per pound: | | | | | |
| New York dealer | 954 | 1,216 | 990 | 1,041 | 1,010 |
| Platts Metals Week composite | 1,240 | 1,575 | 1,283 | 1,352 | NA |
| London Metal Exchange, cash | 925 | 1,184 | 957 | 1,002 | 980 |
| Kuala Lumpur | 922 | 1,188 | 958 | 1,012 | 980 |
| Stocks, consumer and dealer, yearend | 6,410 | 5,880 | 6,140 | 6,500 | 6,900 |
| Net import reliance[2] as a percentage of apparent consumption | 73 | 73 | 74 | 72 | 74 |

**Recycling:** About 14,000 tons of tin from old and new scrap was recycled in 2014. Of this, about 11,200 tons was recovered from old scrap at 2 detinning plants and about 75 secondary nonferrous metal-processing plants.

**Import Sources (2010–13):** Peru, 40%; Bolivia, 17%; Indonesia, 15%; Malaysia, 12%; and other, 16%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Unwrought tin: | | |
| Tin, not alloyed | 8001.10.0000 | Free. |
| Tin alloys, containing, by weight: | | |
| 5% or less of lead | 8001.20.0010 | Free. |
| More than 5% but not more than 25% of lead | 8001.20.0050 | Free. |
| More than 25% of lead | 8001.20.0090 | Free. |
| Tin waste and scrap | 8002.00.0000 | Free. |

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

**Government Stockpile:**

Stockpile Status—9–30–14[3]

| Material | Inventory | Disposal Plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|
| Tin | 4,020 | *804 | — |

Prepared by **C. Schuyler Anderson [(703) 648–4985, csanderson@usgs.gov]**

# TIN

**Events, Trends, and Issues:** Apparent consumption of tin in the United States increased by 6% in 2014 compared with consumption in 2013. Peru remained the primary supplier of tin to the United States, and recycling rates of tin remained unchanged from those in 2013. While the estimated annual prices for tin declined slightly, they continued to fluctuate through several cycles. The New York dealer price averaged 1,028 cents per pound in January and, coinciding with new export restrictions in Indonesia, rose to an average of 1,095 cents per pound in April, the highest monthly level since August 2011. By October, however, the average price had fallen back below 1,000 cents per pound as supply shortages failed to materialize. Platts Metals Composite prices for tin were discontinued in 2014, and the U.S. Geological Survey will use the New York Dealer price for future calculations.

In 2013, Indonesia, the world's leading exporter of tin, created the Indonesia Tin Exchange (ICDX) to allow tin to be traded within Indonesia, and also reduce reliance on foreign trading houses for prices. In 2014, Indonesia modified their new regulations of tin exports involving the ICDX. The primary modification was restricting tin content in solder to a maximum of 99.9% tin, preventing pure tin ingots being sold as solder. This regulation is an attempt to ensure that correct taxes and fees are applied to tin exports from Indonesia and the ICDX. This regulation had the dual effect of raising tin solder prices, and improving tracking of exports from Indonesia. However, the London Metal Exchange remains the largest market for tin options and futures, and it continues to influence the price of tin, dampening the impact of the new ICDX regulations.

**World Mine Production and Reserves:** Reserves figures were revised for Brazil based on new data from the Instituto Brasileiro de Mineração. Reserves figures for Peru were revised based on data from the Ministerio de Energia y Minas del Perú. Reserves figures for Australia were revised based on data from Geoscience Australia.

| | Mine production | | Reserves[4] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | — | — | — |
| Australia | 6,470 | 6,100 | 370,000 |
| Bolivia | 19,300 | 18,000 | 400,000 |
| Brazil | 12,000 | 12,000 | 700,000 |
| Burma | 11,000 | 11,000 | NA |
| China | 110,000 | 125,000 | 1,500,000 |
| Congo (Kinshasa) | 3,000 | 3,000 | NA |
| Indonesia | 95,200 | 84,000 | 800,000 |
| Laos | 800 | 800 | NA |
| Malaysia | 3,700 | 3,500 | 250,000 |
| Nigeria | 570 | 500 | NA |
| Peru | 23,700 | 23,700 | 80,000 |
| Russia | 420 | 600 | 350,000 |
| Rwanda | 1,900 | 2,000 | NA |
| Thailand | 200 | 200 | 170,000 |
| Vietnam | 5,400 | 5,400 | NA |
| Other countries | 100 | 100 | 180,000 |
| World total (rounded) | 294,000 | 296,000 | 4,800,000 |

**World Resources:** U.S.-identified resources of tin, 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, China, Indonesia, and Russia, are extensive and, if developed, could sustain recent annual production rates well into the future.

**Substitutes:** Aluminum, glass, paper, plastic, or tin-free steel substitute for tin in cans and containers. Other materials that substitute for tin are epoxy resins for solder; aluminum alloys, 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 old scrap + imports – exports + adjustments for Government and industry stock changes.

[2]Defined as imports - exports + adjustments for Government and industry stock changes.

[3]See Appendix B for definitions.

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

*Correction posted February 4, 2015.

# TITANIUM AND TITANIUM DIOXIDE[1]

(Data in metric tons unless otherwise noted)

**Domestic Production and Use:** Titanium sponge metal was produced by three operations in Nevada and Utah, and titanium ingot was produced by 10 operations in 8 states. Domestic and imported ingot was consumed by numerous firms to produce wrought products and castings. In 2014, an estimated 75% of titanium metal was used in aerospace applications. The remaining 25% was used in armor, chemical processing, marine hardware applications, medical implants, power generation, sporting goods, and other applications. Assuming an average purchase price of $11.20 per kilogram, the value of sponge metal consumed was about $280 million.

In 2014, titanium dioxide ($TiO_2$) pigment, which was produced by four companies at six facilities in five States, was valued at about $4.4 billion. The estimated end-use distribution of $TiO_2$ pigment consumption was paint (includes lacquers and varnishes), 62%; plastic, 24%; paper, 11%; and other, 3%. Other uses of $TiO_2$ included catalysts, ceramics, coated fabrics and textiles, floor coverings, printing ink, and roofing granules.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Titanium sponge metal: | | | | | |
| Production | W | W | W | W | W |
| Imports for consumption | 20,500 | 33,800 | 33,600 | 19,900 | 15,300 |
| Exports | 293 | 256 | 1,420 | 1,860 | 2,490 |
| Consumption, reported | 34,900 | 48,400 | 35,100 | 24,600 | 25,000 |
| Price, dollars per kilogram, yearend | 9.62 | 10.35 | 11.78 | 11.57 | 11.20 |
| Stocks, industry yearend[e] | 10,500 | 10,800 | 18,100 | 25,200 | 24,300 |
| Employment, number[e] | 300 | 300 | 300 | 300 | 300 |
| Net import reliance[2] as a percentage of reported consumption | 72 | 69 | 71 | 44 | 51 |
| Titanium dioxide: | | | | | |
| Production | 1,320,000 | 1,290,000 | 1,140,000 | 1,280,000 | 1,310,000 |
| Imports for consumption | 204,000 | 200,000 | 203,000 | 213,000 | 235,000 |
| Exports | 758,000 | 789,000 | 624,000 | 670,000 | 685,000 |
| Consumption, apparent[3] | 767,000 | 706,000 | 722,000 | 826,000 | 860,000 |
| Producer price index, yearend | 194 | 268 | 268 | 236 | 237 |
| Employment, number[e] | 3,400 | 3,400 | 3,400 | 3,400 | 3,400 |
| Net import reliance[2] as a percentage of apparent consumption | E | E | E | E | E |

**Recycling:** About 50,000 tons of scrap metal was recycled by the titanium industry in 2014. Estimated use of titanium scrap by the steel industry was about 11,000 tons; by the superalloy industry, 1,100 tons; and in other industries, 1,000 tons.

**Import Sources (2010–13):** Sponge metal: Japan, 54%; Kazakhstan, 24%; China; 12%; and other, 10%. Titanium dioxide pigment: Canada, 39%; China, 19%; Germany, 7%; and other, 35%.

| **Tariff:** **Item** | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| 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 | 8108.20.0000 | 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. |

**Depletion Allowance:** Not applicable.

**Government Stockpile:** None.

Prepared by **George M. Bedinger [(703) 648–6183, gbedinger@usgs.gov]**

# TITANIUM AND TITANIUM DIOXIDE

**Events, Trends, and Issues:** Domestic production of $TiO_2$ pigment was 1.31 million tons, a 2% increase compared with that in 2013. Domestic consumption was estimated to have increased by 5% in 2014 due to increased housing starts and new home sales. In China, a new chloride-route pigment plant was scheduled to begin production in the first quarter of 2015 with a capacity of 100,000 tons per year. In Mexico, a new chloride-route pigment plant was scheduled to begin production in 2016 with a capacity of 200,000 tons per year.

Domestic consumption of titanium sponge in 2014 was estimated to be essentially unchanged from that of 2013. Although titanium sponge consumption and end-of-year stocks in 2014 remained at levels close to those in 2013, imports of titanium sponge decreased by about 23% from those in 2012 owing to a slowdown in aircraft production. Due to progress made in certifying the titanium sponge product at its new plant in Rowley, UT, one of the three U.S. producers of titanium sponge permanently closed its older titanium sponge plant in Albany, OR, which had been idle since 2009, the same year the new plant in Rowley became operational. The completion of the premium quality certification process at Rowley was expected to be complete in 2015 and would enable the plant to produce titanium sponge for use in rotating jet engine parts.

Excluding domestic production, global production of titanium sponge in 2014 was estimated to have decreased by 8% owing to overcapacity and increased inventories. One of the two Japanese sponge producers announced joint venture plans with a Saudi Arabia-based pigment company to construct a new titanium sponge plant in Yanbu, Saudi Arabia. The plant, located adjacent to a titanium dioxide pigment plant, was expected to begin production in 2017 and have a capacity of 15,600 tons per year.

**World Sponge Metal Production and Sponge and Pigment Capacity:**

| | Sponge production | | Capacity 2014[4] | |
|---|---|---|---|---|
| | 2013 | 2014[e] | Sponge | Pigment |
| United States | W | W | 24,000 | 1,470,000 |
| Australia | — | — | — | 280,000 |
| Belgium | — | — | — | 74,000 |
| Canada | — | — | — | 100,000 |
| China[e] | 105,000 | 110,000 | 114,000 | 2,000,000 |
| Finland | — | — | — | 130,000 |
| France | — | — | — | 125,000 |
| Germany | — | — | — | 440,000 |
| Italy | — | — | — | 80,000 |
| Japan[e] | 42,000 | 25,000 | 57,000 | 310,000 |
| Kazakhstan[e] | 12,000 | 9,000 | 27,000 | 1,000 |
| Mexico | — | — | — | 130,000 |
| Russia[e] | 44,000 | 42,000 | 46,500 | 20,000 |
| Spain | — | — | — | 80,000 |
| Ukraine[e] | 6,300 | 6,000 | 10,000 | 120,000 |
| United Kingdom | — | — | — | 300,000 |
| Other countries | — | — | — | 900,000 |
| World total (rounded) | [5]209,000 | [5]192,000 | 279,000 | 6,560,000 |

**World Resources:**[6] Resources and reserves of titanium minerals are discussed under Titanium Mineral Concentrates. The commercial feedstocks for titanium are ilmenite, leucoxene, rutile, slag, and synthetic rutile.

**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]Yearend operating capacity.
[5]Excludes U.S. production.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.

# TITANIUM MINERAL CONCENTRATES[1]

(Data in thousand metric tons of contained $TiO_2$ unless otherwise noted)

**Domestic Production and Use:** Two firms produced ilmenite and rutile concentrates from surface-mining operations in Florida and Virginia. Based on reported data through October 2014, the estimated value of titanium mineral concentrates consumed in the United States in 2014 was $835 million. Zircon was a coproduct of mining from ilmenite and rutile deposits. About 95% of titanium mineral concentrates was consumed by domestic titanium dioxide ($TiO_2$) pigment producers. The remaining 5% was used in welding-rod coatings and for manufacturing carbides, chemicals, and metal.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production[2] (rounded) | 200 | 300 | 300 | 200 | 100 |
| Imports for consumption | 1,040 | 1,010 | 1,110 | 1,190 | 1,050 |
| Exports,[e] all forms | 11 | 16 | 24 | 7 | 2 |
| Consumption, estimated | 1,230 | 1,300 | 1,390 | 1,390 | 1,150 |
| Price, dollars per metric ton: | | | | | |
| Ilmenite, bulk, minimum 54% $TiO_2$, f.o.b. Australia[3] | 75 | 195 | 300 | 265 | 165 |
| Rutile, bulk, minimum 95% $TiO_2$, f.o.b. Australia[3] | 780 | 1,350 | 2,200 | 1,250 | 975 |
| Slag, 80%–95% $TiO_2$[4] | 431–451 | 463–489 | 694–839 | 538–777 | 699–774 |
| Employment, mine and mill, number[e] | 178 | 195 | 195 | 195 | 236 |
| Net import reliance[5] as a percentage of apparent consumption | 65 | 77 | 78 | 86 | 91 |

**Recycling:** None.

**Import Sources (2010–13):** South Africa, 40%; Australia, 21%; Canada, 18%; Mozambique, 4%; and others, 17%.

| Tariff: Item | Number | Normal Trade Relations 12–31–13 |
|---|---|---|
| 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 consumption of titanium mineral concentrates was estimated to have decreased by 8% in 2014 compared with that in 2013. Employment at domestic mining operations increased, however, due to development of a new heavy-mineral mine in Georgia.

Domestic production of titanium mineral concentrates continued at one operation near Starke, FL, and two near Stony Creek, VA. In May, a new heavy-mineral mine started up in Charlton County, GA, and a second mine in Brantley County, GA, was expected to begin production in the fourth quarter 2015. A mineral sands plant in Pierce County, GA, was being constructed to process the heavy minerals from the two new mines and was expected to be completed in the second quarter 2015. Mining at one of the two Virginia operations was halted in April, and the associated mineral separation plant operated at reduced capacity, in order to draw down existing inventories. The operator of the two mines in Virginia announced the decision to mine out deposits at both Virginia operations without further investment and was expected to compete mining and processing activities at these locations at the end of 2015.

Globally, three heavy-mineral concentrate prospects began production in 2014. In South Africa, the Tormin project began production of zircon and rutile concentrates in January and was expected to produce 48,000 tons per year of nonmagnetic concentrate grading 81% zircon and 11.6% rutile over a 4-year mine life. In Kenya, production of titanium mineral concentrates at the Kwale project began in February. Production of ilmenite and rutile was expected to be 360,000 tons per year and 80,000 tons per year, respectively, during a mine life of 13 years. In Senegal, production began at the Grande Cote in March 2014 with the first shipment of ilmenite made in August. At full production capacity the Grand Cote project was expected to produce about 575,000 tons per year of ilmenite during a mine life of more than 20 years. Heavy-mineral exploration and mining projects were also underway in Australia, Brazil, Madagascar, Mozambique, Tanzania, and Sri Lanka.

Prepared by **George M. Bedinger [(703) 648–6183, gbedinger@usgs.gov]**

# TITANIUM MINERAL CONCENTRATES

**World Mine Production and Reserves:** Reserves for Australia were revised based on a Geoscience Australia publication.

| | Mine production | | Reserves[6] |
| --- | --- | --- | --- |
| | 2013 | 2014[e] | |
| Ilmenite: | | | |
| United States[2] | [7]200 | [7]100 | 2,000 |
| Australia | 960 | 1,100 | 170,000 |
| Brazil | 100 | 70 | 43,000 |
| Canada[8] | 770 | 900 | 31,000 |
| China | 1,020 | 1,000 | 200,000 |
| India | 340 | 340 | 85,000 |
| Madagascar | 264 | 340 | 40,000 |
| Mozambique | 430 | 500 | 14,000 |
| Norway | 498 | 400 | 37,000 |
| South Africa[8] | 1,190 | 1,100 | 63,000 |
| Sri Lanka | 32 | 32 | NA |
| Ukraine | 150 | 210 | 5,900 |
| Vietnam | 720 | 500 | 1,600 |
| Other countries | 60 | 90 | 26,000 |
| World total (ilmenite, rounded) | 6,730 | 6,680 | 720,000 |
| Rutile: | | | |
| United States | ([9]) | ([9]) | ([9]) |
| Australia | 423 | 480 | 28,000 |
| India | 24 | 26 | 7,400 |
| Madagascar | 8 | 7 | NA |
| Malaysia | 14 | 14 | NA |
| Sierra Leone | 81 | 120 | NA |
| South Africa | 59 | 65 | 8,300 |
| Ukraine | 50 | 50 | 2,500 |
| Other countries | 8 | 8 | 400 |
| World total (rutile, rounded) | [9]667 | [9]770 | 47,000 |
| World total (ilmenite and rutile, rounded) | 7,400 | 7,450 | 770,000 |

**World Resources:** Ilmenite accounts for about 92% 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 one significant digit to avoid disclosing company proprietary data.
[3]Source: Industrial Minerals; yearend average of high-low price.
[4]Landed duty-paid value based on U.S. imports for consumption. Data series revised to reflect annual average price range of significant importing countries.
[5]Defined as imports – exports.
[6]See Appendix C for resource/reserve definitions and information concerning data sources.
[7]Includes rutile.
[8]Mine production is primarily used to produce titaniferous slag.
[9]U.S. rutile production and reserves data are included with ilmenite.

# TUNGSTEN

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

**Domestic Production and Use:** A tungsten mine in California produced concentrates in 2014. Approximately seven companies in the United States processed tungsten concentrates, ammonium paratungstate, tungsten oxide, and (or) scrap to make tungsten powder, tungsten carbide powder, and (or) tungsten chemicals. Nearly 60% of the tungsten consumed in the United States was used in cemented carbide parts for cutting and wear-resistant materials, primarily in the construction, metalworking, mining, and oil- and gas-drilling industries. The remaining tungsten was consumed to make tungsten heavy alloys for applications requiring high density; electrodes, filaments, wires, and other components for electrical, electronic, heating, lighting, and welding applications; steels, superalloys, and wear-resistant alloys; and chemicals for various applications. The estimated value of apparent consumption in 2014 was approximately $800 million.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine | NA | NA | NA | NA | NA |
| Secondary | 5,680 | 11,000 | 9,180 | 8,610 | 8,300 |
| Imports for consumption: | | | | | |
| Concentrate | 2,740 | 3,640 | 3,650 | 3,690 | 4,100 |
| Other forms | 9,690 | 9,600 | 8,060 | 8,480 | 8,900 |
| Exports: | | | | | |
| Concentrate | 276 | 169 | 203 | 1,060 | 1,500 |
| Other forms | 4,350 | 6,960 | 6,530 | 6,670 | 5,800 |
| Government stockpile shipments: | | | | | |
| Concentrate | 2,060 | 1,180 | 1,780 | 2,100 | 280 |
| Other forms | ([1]) | 46 | ([1]) | — | — |
| Consumption: | | | | | |
| Reported, concentrate | 4,820 | W | W | W | W |
| Apparent,[2, 3] all forms | 15,500 | 18,100 | 15,000 | 14,700 | 14,500 |
| Price, concentrate, dollars per mtu $WO_3$,[4] average, U.S. spot market, Platts Metals Week | 183 | 248 | 358 | 358 | 350 |
| Stocks, industry, yearend: | | | | | |
| Concentrate | W | W | W | W | W |
| Other forms | 2,530 | W | W | W | W |
| Net import reliance[5] as a percentage of apparent consumption | 63 | 40 | 39 | 41 | 43 |

**Recycling:** In 2014, the estimated tungsten contained in scrap consumed by processors and end users represented 53% of apparent consumption of tungsten in all forms.

**Import Sources (2010–13):** Tungsten contained in ores and concentrates, intermediate and primary products, wrought and unwrought tungsten, and waste and scrap: China, 43%; Bolivia, 8%; Canada, 6%; Germany, 5%; and other, 38%.

| **Tariff:** Item | Number | Normal Trade Relations[6] 12–31–14 |
|---|---|---|
| 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. |

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

**Government Stockpile:**

**Stockpile Status—9–30–14[7]**

| Material | Inventory | Disposal Plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|
| Metal powder | 125 | *90 | — |
| Ores and concentrates | 11,600 | 3,580 | 322 |

Prepared by **Kim B. Shedd [(703) 648–4974, kshedd@usgs.gov]**

# TUNGSTEN

**Events, Trends, and Issues:** World tungsten supply was dominated by Chinese production and exports. China was also the world's leading tungsten consumer. China's Government has regulated its tungsten industry by limiting the number of exploration, mining, and export licenses; limiting or forbidding foreign investment; imposing constraints on mining and processing; establishing quotas on production and exports; adjusting export quotas to favor value-added downstream materials and products; and imposing export taxes on tungsten materials. As a result of a World Trade Organization (WTO) ruling that China's export restraints were inconsistent with its WTO obligations, China canceled its tungsten export quota for 2015, but vowed to strengthen its control and regulation of tungsten mining, production, and distribution.

In the next few years, mine production from outside China is expected to increase. Numerous companies worked to develop tungsten deposits, produce tungsten concentrate from stockpiled tailings, or restart production from inactive mines in Asia, Australia, Europe, North America, and South America. The amount, location, and timing of future production will depend on the companies' abilities to acquire funding. Increased production capacity for ammonium paratungstate is also planned. Scrap will continue to be an important source of raw material for the tungsten industry, worldwide.

**World Mine Production and Reserves:**

| | Mine production | | Reserves[8] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | NA | NA | 140,000 |
| Australia | 320 | 600 | 160,000 |
| Austria | 850 | 850 | 10,000 |
| Bolivia | 1,250 | 1,300 | 53,000 |
| Canada | 2,130 | 2,200 | 290,000 |
| China | 68,000 | 68,000 | 1,900,000 |
| Congo (Kinshasa) | 830 | 800 | NA |
| Portugal | 692 | 700 | 4,200 |
| Russia | 3,600 | 3,600 | 250,000 |
| Rwanda | 730 | 700 | NA |
| Vietnam | 1,660 | 2,000 | 87,000 |
| Other countries | 1,290 | 1,700 | 360,000 |
| World total (rounded) | [3]81,400 | [3]82,400 | 3,300,000 |

**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]The sum of U.S. net import reliance and secondary production.
[3]Does not include U.S. mine production.
[4]A metric ton unit (mtu) of tungsten trioxide ($WO_3$) contains 7.93 kilograms of tungsten.
[5]Defined as imports – exports + adjustments for Government and industry stock changes.
[6]No tariff for Canada. Tariffs for other countries for some items may be eliminated under special trade agreements.
[7]See Appendix B for definitions.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.
*Correction posted February 4, 2015.

# VANADIUM

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

**Domestic Production and Use:** In 2014, seven U.S. firms that compose most of the domestic vanadium industry produced ferrovanadium, vanadium pentoxide, vanadium metal, and vanadium-bearing chemicals or specialty alloys by processing materials such as petroleum residues, spent catalysts, utility ash, and vanadium-bearing pig iron slag. In 2009–2013, small amounts of vanadium were produced as a coproduct from the mining of uraniferous sandstones on the Colorado Plateau. All coproduct vanadium production for 2014 was suspended. Metallurgical use, primarily as an alloying agent for iron and steel, accounted for about 93% of the domestic vanadium consumption in 2014. 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:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, mine, mill | 1,060 | 590 | 106 | 591 | — |
| Imports for consumption: | | | | | |
| Ferrovanadium | 1,340 | 2,220 | 4,190 | 3,710 | 4,200 |
| Vanadium pentoxide, anhydride | 4,000 | 2,810 | 1,640 | 2,040 | 3,400 |
| Oxides and hydroxides, other | 167 | 886 | 905 | 205 | 200 |
| Aluminum-vanadium master alloys (gross weight) | 63 | 86 | 115 | 169 | 180 |
| Ash and residues | 1,010 | 1,510 | 2,210 | 4,190 | 3,500 |
| Sulfates | 48 | 42 | 29 | 30 | 32 |
| Vanadates | 158 | 303 | 280 | 276 | 300 |
| Vanadium metal, including waste & scrap (gross weight) | 10 | 44 | 154 | 35 | 22 |
| Exports: | | | | | |
| Ferrovanadium | 611 | 314 | 337 | 259 | 350 |
| Vanadium pentoxide, anhydride | 140 | 98 | 62 | 77 | 120 |
| Oxides and hydroxides, other | 1,100 | 254 | 287 | 358 | 280 |
| Aluminum-vanadium master alloys (gross weight) | 133 | 318 | 432 | 347 | 300 |
| Vanadium metal, including waste & scrap (gross weight) | 21 | 102 | 26 | 52 | 50 |
| Consumption: | | | | | |
| Apparent | 5,940 | 7,580 | 8,540 | 10,200 | 10,800 |
| Reported | 5,030 | 4,140 | 3,980 | 3,980 | 4,000 |
| Price, average, dollars per pound $V_2O_5$ | 6.46 | 6.76 | 6.49 | 6.04 | 5.80 |
| Stocks, consumer, yearend | 248 | [1]193 | [1]223 | [1]220 | [1]235 |
| Net import reliance[2] as a percentage of apparent consumption | 82 | 92 | 99 | 94 | 100 |

**Recycling:** The quantity of vanadium recycled from spent chemical process catalysts was significant and may compose as much as 40% of total supply. 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 (2010–13):** Ferrovanadium: Czech Republic, 39%; Canada, 23%; Republic of Korea, 19%; Austria, 17%; and other, 2%. Vanadium pentoxide: Russia, 42%; South Africa, 38%; China, 15%; and other, 5%.

**Tariff:** Ash, residues, slag, and waste and scrap enter duty-free.

| Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Vanadium pentoxide anhydride | 2825.30.0010 | 5.5% ad val. |
| Vanadium oxides and hydroxides, other | 2825.30.0050 | 5.5% ad val. |
| Vanadates | 2841.90.1000 | 5.5% ad val. |
| Ferrovanadium | 7202.92.0000 | 4.2% ad val. |
| Vanadium and articles thereof[3] | 8112.99.2000 | 2.0% ad val. |

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

**Government Stockpile:** None.

Prepared by **Désirée E. Polyak [(703) 648–4909, dpolyak@usgs.gov]**

# VANADIUM

**Events, Trends, and Issues:** U.S. reported consumption of vanadium in 2014 was about the same as that of 2013. Among the major uses for vanadium, production of carbon, full-alloy, and high-strength low-alloy steels accounted for 15%, 43%, and 35%, respectively, of domestic consumption. U.S. imports for consumption of vanadium in 2014 increased by 11% from those of the previous year. U.S. exports increased slightly from those of the previous year.

Vanadium pentoxide ($V_2O_5$) prices stayed at $5.80 per pound from January 2014 through June 2014. U.S. ferrovanadium (FeV) prices slowly increased starting in November 2013 and continued to increase into 2014. In June 2014, prices averaged $19.06 per pound of FeV.

**World Mine Production and Reserves:** Reserves for Australia were updated with data from Geoscience Australia.

| | Mine production | | Reserves[4] |
|---|---|---|---|
| | 2013 | 2014[e] | (thousand metric tons) |
| United States | 591 | — | 45 |
| Australia | 400 | — | 1,800 |
| China | 41,000 | 41,000 | 5,100 |
| Russia | 15,000 | 15,000 | 5,000 |
| South Africa | 21,000 | 21,000 | 3,500 |
| Other countries | 600 | 600 | NA |
| World total (rounded) | 79,000 | 78,000 | 15,000 |

**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 amounts 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. While domestic resources and secondary recovery are adequate to supply a large portion of domestic needs, a substantial part 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 in aerospace titanium alloys.

[e]Estimated. NA Not available. — Zero.
[1]Does not include vanadium pentoxide.
[2]Defined as imports – exports + adjustments for Government and industry stock changes.
[3]Aluminum-vanadium master alloy consisting of 35% aluminum and 64.5% vanadium.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.

# 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. Most of the vermiculite concentrate was shipped to 18 exfoliating plants in 11 States. The end uses for exfoliated vermiculite were estimated to be agriculture/horticulture, 50%; lightweight concrete aggregates (including cement premixes, concrete, and plaster), 20%; insulation, 5%; and other, 25%.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production[e, 1] | 100 | 100 | 100 | 100 | 100 |
| Imports for consumption[e, 2] | 29 | 53 | 57 | 36 | 38 |
| Exports[e] | 2 | 2 | 2 | 2 | 2 |
| Consumption, apparent, concentrate[3] | 130 | 150 | 160 | 130 | 140 |
| Consumption, exfoliated[e] | 67 | 62 | 59 | 64 | 65 |
| Price, range of value, concentrate, dollars per ton, ex-plant[4] | 100–400 | 115–460 | 145–525 | 145-565 | 150-580 |
| Employment, number[e] | 80 | 80 | 75 | 70 | 75 |
| Net import reliance[5] as a percentage of apparent consumption | 20 | 30 | 35 | 25 | 25 |

**Recycling:** Insignificant.

**Import Sources (2010–13):** South Africa, 44%; Brazil, 28%; China, 26%; and other, 2%.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| 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, U.S. exports were about the same in 2014 as those of 2013. U.S. imports, excluding any material from Canada and Mexico, were estimated to be about 38,000 tons in 2014, slightly more than in 2013. Supplies of coarse grades remained tight, and prices rose slightly in 2014.

Prepared by **Arnold O. Tanner [(703) 648–4791, atanner@usgs.gov]**

# VERMICULITE

An Australian company postponed reopening its East African Namekara vermiculite mine in Uganda. The delay was the result of an oversupply of the medium-to-finer grades in the world market; sluggish market conditions in Europe, its largest market; and transportation and related infrastructure-improvement issues. Although no vermiculite was produced, removal of overburden continued. The Namekara deposit has sufficient resources for more than 50 years of production and is a portion of the larger East African vermiculite project, which has about 55 million tons of inferred resources and is considered to be one of the world's largest deposits.

In July, the sale of the leading vermiculite producer in South Africa was completed to a consortium of South African and Chinese parastatal and private companies. Reserves identified on properties adjacent to and near ongoing vermiculite mining operations could enable increased vermiculite production and extend the mine's current expected 24-year mine life.

A Brazilian company, which expanded production capacity at its vermiculite mine in central Brazil in 2013, was developing another deposit near Brasilia. The new operation would bring the company's total production capacity to 200,000 tons per year by 2016.

**World Mine Production and Reserves:** The estimates of reserves were revised for Brazil based on new information from official Government sources.

| | Mine production | | Reserves[6] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States[e, 1] | 100 | 100 | 25,000 |
| Brazil | 55 | 50 | 13,100 |
| Bulgaria | 19 | 20 | NA |
| China | 15 | 50 | NA |
| India | 11 | 15 | 1,700 |
| Russia | 20 | 25 | NA |
| South Africa | 128 | 130 | 14,000 |
| Other countries | 10 | 10 | 15,000 |
| World total | 358 | 400 | NA |

**World Resources:** Marginal reserves of vermiculite in Colorado, Nevada, North Carolina, Texas, and Wyoming are estimated to be 2 million to 3 million tons. Reserves have been reported in Australia, Brazil, China, Russia, South Africa, Uganda, the United States, Zimbabwe, and some other countries. However, reserve information comes from many sources, and in most cases, it is not clear whether the numbers refer to vermiculite alone or vermiculite plus host rock and overburden.

**Substitutes:** Expanded perlite is a substitute for vermiculite in lightweight concrete and plaster. Other more dense but less costly material substitutes in these applications are expanded clay, shale, slag, and slate. Alternate materials for loosefill 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 and used by producers. Data are rounded to one significant digit to avoid disclosing company proprietary data.
[2]Excludes Canada and Mexico.
[3]Rounded to two significant digits to protect proprietary data.
[4]Source: Mining Engineering.
[5]Defined as imports – exports.
[6]See Appendix C for resource/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. Domestic 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 USGS does not collect consumption statistics for wollastonite. Plastics and rubber markets (thermoplastic and thermoset resins and elastomer compounds), were estimated to have accounted for more than 25% of U.S. use of wollastonite, followed by ceramics (frits, sanitaryware, and tile), paint (architectural and industrial paints), metallurgical applications (flux and conditioner), friction products (primarily brake linings), and miscellaneous uses (including adhesives, concrete, glass, and sealants). Globally, ceramics were estimated to account for more than 30% of sales, followed by polymers and paint. Lesser global uses for wollastonite also included miscellaneous construction products, friction materials, and metallurgical applications.

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 its resistance to weathering, reduces gloss, reduces 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 the 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, inert, stable at high temperatures, and improves flexural and tensile strength.

**Salient Statistics—United States:** U.S. production was withheld to protect company proprietary data. In 2014, U.S. production and apparent consumption increased compared with those in 2013. Comprehensive trade data are not available (the United States was a net exporter of wollastonite). Exports were estimated to be less than 8,000 tons and imports probably were less than 4,000 tons in 2014. Prices for wollastonite were reported in the trade literature to range from $80 to $440 per metric ton. Products with finer grain sizes and acicular (highly elongated) particles sold for higher prices. Surface treatment, when necessary, also increased the selling price.

**Recycling:** None.

**Import Sources (2010–13):** Comprehensive trade data are not available, but wollastonite was imported from China, Finland, India, and Mexico.

**Tariff:**

| Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Mineral substances not elsewhere specified or included | 2530.90.8050 | Free. |

**Depletion Allowance:** 10% (Domestic and foreign).

**Government Stockpile:** None.

Prepared by **Robert L. Virta [(703) 648–7726, rvirta@usgs.gov]**

# WOLLASTONITE

**Events, Trends, and Issues:** U.S. production and consumption of wollastonite increased in 2014. Exports probably increased slightly and imports may have declined slightly in 2014. Sales to domestic construction-related markets, such as adhesives, caulks, cement board, ceramic tile, paints, stucco, and wallboard, were likely to have increased in 2014 because of growth in residential and commercial construction. With increased domestic manufacturing, sales of wollastonite to the manufacturing industries, such as metal casting and processing, paint, plastics, and rubber, probably increased in 2014. In Western Europe, demand for wollastonite may have increased just slightly in 2014 because of the effect of economic uncertainties on construction and manufacturing. Consumption in Asia continued to increase, although at a slower pace than in 2013.

Despite receiving voter approval for a State proposition to allow the leading U.S. producer of wollastonite to explore and mine 81 hectares of land in the Adirondack Forest Preserve adjacent to its current mine, a restraining order was issued by the Albany County (New York) Supreme Court suspending any exploration activity, pending further review.

**World Mine Production and Reserves:** Production data for wollastonite are not available for many countries.

| | Mine production | | Reserves[1] |
|---|---|---|---|
| | 2013[e] | 2014[e] | |
| United States | W | W | World reserves of wollastonite were estimated to exceed 90 million tons. Many deposits, however, have not been surveyed, making accurate reserve estimates unavailable. |
| China | 300,000 | 300,000 | |
| Finland | 11,500 | 11,500 | |
| India | 160,000 | 145,000 | |
| Mexico | 55,000 | 55,000 | |
| Other countries | 8,000 | 8,000 | |
| World total (rounded)[2, 3] | 535,000 | 520,000 | |

**World Resources:** World resources have not been estimated for wollastonite. Large deposits of wollastonite were in China, Finland, India, Mexico, and the United States. Smaller, but significant, deposits were 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/reserve definitions and information concerning data sources.
[2]Excludes U.S. production.
[3]Refined concentrate production.

# YTTRIUM[1]

[Data in metric tons of yttrium oxide ($Y_2O_3$) content unless otherwise noted]

**Domestic Production and Use:** Rare earths were mined by one U.S. company in 2014. Bastnasite, a rare-earth fluorocarbonate mineral, was mined as a primary product at Mountain Pass, CA. Domestic production of rare-earth oxide mineral concentrate in 2014 was estimated to be 5,000 tons in 2014, up from an estimated 3,500 tons in 2013. Yttrium was estimated to represent 0.12 percent of the rare-earth elements in the Mountain Pass bastnäsite ore.

The leading end uses of yttrium, in decreasing order, were in phosphors, ceramics, and metallurgy. Yttrium was used in phosphor compounds for flat panel displays and various lighting applications. 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.

| **Salient Statistics—United States:** | **2010** | **2011** | **2012** | **2013** | **2014[e]** |
|---|---|---|---|---|---|
| Production, mine[2] | — | — | NA | NA | NA |
| Imports for consumption: | | | | | |
| Yttrium, alloys, compounds, and metal[e, 3] | 670 | 550 | 160 | 200 | 200 |
| Exports, in ore and concentrate | NA | NA | NA | NA | NA |
| Consumption, estimated[4] | 670 | 550 | 160 | 200 | 200 |
| Price,[e] dollars: | | | | | |
| Yttrium oxide, per kilogram, minimum 99.999 purity[5] | 25–27 | 136–141 | 86–91 | 23–27 | 15–17 |
| Yttrium metal, per kilogram, minimum 99.9% purity[5] | 50–60 | 162–172 | 141–151 | 60–70 | 55–65 |
| Net import reliance[e, 6, 7] as a percentage of apparent consumption | 100 | 100 | >95 | >95 | >95 |

**Recycling:** Small quantities, primarily from phosphors.

**Import Sources (2010–13):** Yttrium compounds, greater than 19% to less than 85% weight percent yttrium oxide equivalent: China, 62%; Japan, 15%; Germany, 12%; Austria, 4%; and other, 7%.

| **Tariff:** Item | **Number** | **Normal Trade Relations 12–31–14** |
|---|---|---|
| Rare-earth metals, scandium and yttrium, whether or not intermixed or interalloyed | 2805.30.0000 | 5.0% ad val. |
| Yttrium-bearing materials and compounds containing by weight >19% to <85% $Y_2O_3$ | 2846.90.4000 | Free. |
| Other rare-earth compounds, including yttrium oxide $\geq$85% $Y_2O_3$ 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:** None.

**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. Processing was primarily at facilities in Guangdong, Jiangsu, and Jiangxi Provinces.

Prepared by **Joseph Gambogi [(703) 648–7718, jgambogi@usgs.gov]**

# YTTRIUM

Globally, yttrium was mainly consumed in the form of high-purity oxide compounds for phosphors. Lesser amounts were consumed in ceramics, electronic devices, lasers, and metallurgical applications. Global consumption of yttrium oxide was estimated to be 6,000 tons. Owing to abundant supply and shrinking demand in some markets, prices for yttrium metal and oxide decreased significantly in 2014, returning prices to levels prior to all-time highs reached in 2011. According to industry reports, increasing popularity of light-emitting-diode (LED) lighting over traditional fluorescent lighting has reduced the consumption of yttrium-based phosphors.

No imports of yttrium-bearing thorium ores and concentrates were reported through September 2014. The most recent reported imports of thorium ores and concentrates occurred in 2012.

According to China's preliminary export statistics, yttrium oxide exports increased in 2014. During the first three quarters of 2014, China exported 718 tons of yttrium oxide, primarily to Japan (53%), Italy (16%), and the United States (10%). Exports to the United States were nearly unchanged compared with those in 2013.

In 2014, the Defense Logistics Agency (DLA) Strategic Materials was seeking to identify sources for yttrium oxide suitable for use by domestic industries. Based on the information collected and other market research, DLA Strategic Materials may release a solicitation for the acquisition of 25 tons of yttrium oxide, which was expected to meet the stockpile requirements to mitigate against a potential supply chain disruption.

In China, according to media reports, the government was reported to be building a national stockpile of rare earths. In 2014, China was expected to add 10,000 tons of rare earths, including 2,500 tons of yttrium oxide. China continued to struggle with illegal mining, processing, and smuggling of rare earths. In India, a processing plant was being commissioned to produce several thousand metric tons of rare-earth compounds derived from monazite. India's monazite was produced at Manavalakurichi (Tamil Nadu), Chavara (Kerala), and Chatrapur (Odisha).

**World Mine Production and Reserves:**[8] World production of yttrium was based almost entirely in China. In 2014, world production was estimated to be 7,000 t. Mine production of rare-earth oxides in Australia, including yttrium oxide, was estimated to be 2,500 tons in 2014 compared with 2,000 tons in 2013. The yttrium oxide content of the rare-earth oxides in Australia's Central Lanthanide deposit was estimated to be 0.76%. 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.

**World Resources:** The world's resources of yttrium are probably very large. Yttrium is associated with most rare-earth deposits. It occurs in various minerals in differing concentrations and occurs in a wide variety of geologic environments, including alkaline granites and intrusives, carbonatites, hydrothermal deposits, laterites, placers, and vein-type deposits. 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. Large resources of yttrium in monazite and xenotime are available worldwide in placer deposits, carbonatites, uranium ores, and weathered clay deposits (ion-adsorption ore). Additional resources of yttrium occur in apatite-magnetite-bearing rocks, deposits of niobium-tantalum minerals, non-placer monazite-bearing deposits, sedimentary phosphate deposits, and uranium ores.

**Substitutes:** Substitutes for yttrium are available for some applications but generally are much less effective. In most uses, especially in electronics, lasers, and phosphors, yttrium is not subject to substitution by other elements. As a stabilizer in zirconia ceramics, yttria (yttrium oxide) may be substituted with calcia (calcium oxide) or magnesia (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]Based on data from the U.S. Census Bureau and the Port Import/Export Reporting Service, JOC Group Inc.
[4]Essentially, all yttrium consumed domestically was imported or refined from imported materials.
[5]Free on board China from Metal-Pages Ltd., Teddington, United Kingdom.
[6]Defined as imports – exports + adjustments for Government and industry stock changes. Insufficient data were available to determine exports and stocks changes and were excluded from the calculation.
[7]Includes yttrium contained in rare-earth ores and concentrates.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.
*Correction posted on March 12, 2015.

# ZEOLITES (NATURAL)

(Data in metric tons unless otherwise noted)

**Domestic Production and Use:** Natural zeolites were mined by nine companies in the United States. About 67,000 tons of natural zeolites were produced in 2014. Chabazite was mined in Arizona; clinoptilolite was mined in California, Idaho, New Mexico, Oregon, and Texas. New Mexico was the leading zeolite-producing State in 2014, followed by Texas, Idaho, Arizona, California, and Oregon.

In 2014, about 65,400 tons of natural zeolites were consumed in the United States. Domestic uses for natural zeolites were, in decreasing order by tonnage, animal feed, pet litter, odor control, cement (primarily down-hole cement applications by the drilling industry), water purification, wastewater treatment, fertilizer carrier, fungicide or pesticide carrier, gas absorbent (and air filtration), oil absorbent, desiccant, aquaculture, and catalyst. The five leading uses accounted for more than 70% of the domestic natural zeolite sales tonnage.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production | 61,300 | 65,400 | 74,000 | 69,500 | 67,600 |
| Sales, mill | 60,000 | 65,200 | 70,500 | 68,300 | 65,400 |
| Imports for consumption[e] | 150 | 150 | 5 | 5 | 5 |
| Exports[e] | 400 | 1,100 | 750 | 200 | 200 |
| Consumption, apparent[e, 1] | 59,800 | 64,200 | 69,800 | 68,100 | 65,200 |
| Price, range of value, dollars per metric ton[2] | 30–900 | 40–800 | 50–800 | 50–800 | 50–800 |
| Net import reliance[3] as a percentage of estimated consumption | E | E | E | E | E |

**Recycling:** Natural zeolites used for such applications as desiccants, gas absorbents, wastewater cleanup, or water purification may be reused after reprocessing of the spent zeolites.

**Import Sources (2010–13):** Comprehensive trade data are not available for natural zeolites. Nearly all exports and imports were synthetic zeolites.

| Tariff: Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Mineral substances not elsewhere specified or included | 2530.90.8050 | Free. |

**Depletion Allowance:** 14% (Domestic and foreign).

**Government Stockpile:** None.

**Events, Trends, and Issues:** U.S. consumption of natural zeolites decreased by 3% in 2014. Because of the markets served by the natural zeolite producers, sales do not always follow economic trends, which have improved in the past 3 years. During the past 20 years, the greatest increase in market sales have been for animal feed, the leading market in 2014. Sales of natural zeolites for cement, odor control, wastewater treatment, and water treatment applications have increased in the past 10 years, although expansion of those markets has not been as great as with animal feed. Sales for pet litter declined during the past 20 years because of competition from other products and shifting of some pet litter sales to other zeolite markets. Although specific data are not available on U.S. trade of natural zeolites, the United States was believed to be a net exporter of natural zeolites in 2014.

Prepared by **Robert L. Virta [(703) 648–7726, rvirta@usgs.gov]**

# ZEOLITES (NATURAL)

**World Mine Production and Reserves:** Natural zeolite production data are not available for most countries. Countries mining large tonnages of zeolites typically use them in low-value applications. The ready availability of zeolite-rich rock at low cost and the shortage of competing minerals and rocks are probably the most important factors encouraging its large-scale use. It is also likely that a significant percentage of the material sold as zeolites in some countries is ground or sawn volcanic tuff that contains only a small amount of zeolites. Examples of such usage are dimension stone (as an altered volcanic tuff), lightweight aggregate, pozzolanic cement, and soil conditioners.

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 that contain low to moderate concentrations of zeolites. These typically are used in high-volume construction applications, and therefore some deposits should be excluded from reserves estimates because it is the rock itself and not its zeolite content that makes the deposit valuable.

| | Mine production | | Reserves[4] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 69,500 | 67,600 | |
| China[5] | 2,000,000 | 2,000,000 | World reserves are |
| Jordan | 15,000 | 13,000 | not determined but are |
| Korea, Republic of | 230,000 | 230,000 | estimated to be large. |
| Turkey | 50,000 | 70,000 | |
| Other countries[5] | 350,000 | 350,000 | |
| World total (rounded) | 2,710,000 | 2,730,000 | |

**World Resources:** World resources have not been estimated for natural zeolites. An estimated 120 million tons of clinoptilolite, chabazite, erionite, mordenite, and phillipsite is present in near-surface deposits in the Basin and Range province in the United States. Resources in the United States may approach 10 trillion tons for zeolite-rich deposits.

**Substitutes:** For pet litter, natural zeolites compete with other mineral-based litters, such as those manufactured using attapulgite, 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. 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, talc, and silica as anticaking and flow-control agents.

[e]Estimated. E Net exporter.
[1]Defined as sales, mill + imports – exports.
[2]Estimate based on values reported by U.S. producers and prices published in the trade literature. Bulk shipments typically range from $100 to $230 per ton.
[3]Defined as imports – exports.
[4]See Appendix C for resource/reserve definitions and information concerning data sources.
[5]Includes materials appropriate for pozzolan applications.

# ZINC

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

**Domestic Production and Use:** The value of zinc mined in 2014, based on zinc contained in concentrate, was about $1.94 billion. Zinc was mined in 4 States at 14 mines operated by 4 companies. Four facilities, one primary and three secondary, operated by three companies produced commercial-grade zinc metal. Of the total reported zinc consumed, about 80% was used in galvanizing, 6% in brass and bronze, 5% in zinc-base alloys, and 9% in other uses.

| Salient Statistics—United States: | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production: | | | | | |
| Mine, zinc in concentrate | 748 | 769 | 738 | 784 | 820 |
| Metal production | | | | | |
| At primary smelters | 120 | 110 | 114 | 106 | 115 |
| At secondary smelters | 129 | 138 | 147 | 127 | 70 |
| Imports for consumption: | | | | | |
| Zinc in ore and concentrate | 32 | 27 | 6 | 3 | — |
| Refined zinc | 671 | 716 | 655 | 713 | 810 |
| Exports: | | | | | |
| Zinc in ore and concentrate | 752 | 653 | 591 | 669 | 650 |
| Refined zinc | 4 | 18 | 14 | 12 | 15 |
| Shipments from Government stockpile | — | — | — | — | — |
| Consumption, apparent, refined zinc[1] | 907 | 939 | 891 | 940 | 990 |
| Price, average, cents per pound: | | | | | |
| North American[2] | 102.0 | 106.2 | 95.8 | 95.6 | 107.5 |
| London Metal Exchange (LME), cash | 98.0 | 99.5 | 88.3 | 86.6 | 98.5 |
| Reported producer and consumer stocks, refined zinc, yearend | 108 | 145 | 156 | 150 | 140 |
| Employment: | | | | | |
| Mine and mill, number[3] | 1,790 | 2,240 | 2,310 | 2,560 | 2,600 |
| Smelter, primary, number | 255 | 244 | 252 | 257 | 257 |
| Net import reliance[4] as a percentage of apparent consumption (refined zinc) | 73 | 74 | 71 | 75 | 81 |

**Recycling:** In 2014, about 52% (95,000 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 (2010–13):** Ore and concentrate: Peru, 74%; Canada, 16%; Mexico, 8%; and Turkey%. Refined metal: Canada, 69%; Mexico, 13%; Peru, 8%; Australia, 4%; and other, 6%. Waste and scrap: Canada, 69%; Mexico, 28%; Dominican Republic, 2%; and other, 1%. Combined total: Canada, 68%; Mexico, 13%; Peru, 9%; and other, 10%.

| **Tariff:** Item | Number | Normal Trade Relations[5] 12–31–14 |
|---|---|---|
| Zinc ores and concentrates, Zn content | 2608.00.0030 | Free. |
| Zinc oxide and 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—9–30–14[6]**

| Material | Inventory | Disposal Plan FY 2014 | Disposals FY 2014 |
|---|---|---|---|
| Zinc | 7 | — | — |

Prepared by **Amy C. Tolcin [(703) 648–4940, atolcin@usgs.gov]**

# ZINC

**Events, Trends, and Issues:** Global zinc mine production in 2014 was 13.3 million tons, essentially unchanged from that of 2013. According to the International Lead and Zinc Study Group, refined zinc production in 2014 increased by 3% to 13.25 million tons, and metal consumption rose by 5% to 13.65 million tons, resulting in a production-to-consumption deficit of about 400,000 tons of refined zinc. Domestic zinc mine production increased by 5% in 2014 from that of 2013 owing to increased production at the Red Dog Mine in Alaska; mill throughput at the mine rose significantly as a result of processing softer ores from the Aqqaluk deposit. The Pend Oreille Mine in Washington reopened in 2014 and began shipping concentrates by yearend. At full production, the mine could produce zinc in concentrate at a rate of 44,000 tons per year. Zinc metal production decreased by 20% owing to a decline in secondary production; a zinc-recycling company closed its smelter in Pennsylvania coincident with the startup of its new 140,000-metric-ton-per-year recycling facility in North Carolina in the second quarter. Technical issues, however, delayed rampup efforts at the new facility in the latter half of the year. Apparent zinc consumption increased by 5% in 2014 as reflected by a rise in net imports of unwrought zinc and a decline in yearend industry stocks. Increased consumption was attributed to increased U.S. residential construction and infrastructure development.

North American Special High Grade (SHG) zinc prices averaged $1.01 per pound in the first quarter of 2014, $1.03 per pound in the second quarter, and $1.14 per pound during the third quarter. North American SHG zinc premiums began the year at about 9.3 cents per pound and remained around that level through April, after which they declined to just under 9 cents per pound by October.

In November, the U.S. Senate Permanent Subcommittee on Investigations released a report revealing that several financial holding companies used their physical commodity activities to gain access to commercially valuable nonpublic information and thus gained unfair trading advantages in these markets. Two banks owned and operated a network of metal warehouses in the United States that stored LME-registered metal, including zinc, during the year.

**World Mine Production and Reserves:** Reserves estimates for Bolivia, Canada, Ireland, Mexico, and other countries were revised based on company data. The reserves estimates for Australia and Peru were revised based on data from Government reports.

| | Mine production[7] | | Reserves[8] |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | 784 | 820 | 10,000 |
| Australia | 1,520 | 1,500 | [9]62,000 |
| Bolivia | 407 | 410 | 4,500 |
| Canada | 426 | 350 | 5,900 |
| China | 5,000 | 5,000 | 43,000 |
| India | 793 | 700 | 11,000 |
| Ireland | 327 | 300 | 1,100 |
| Kazakhstan | 362 | 330 | 10,000 |
| Mexico | 643 | 700 | 16,000 |
| Peru | 1,350 | 1,300 | 29,000 |
| Other countries | 1,800 | 1,900 | 42,000 |
| World total (rounded) | 13,400 | 13,300 | 230,000 |

**World Resources:** Identified zinc resources of the world are about 1.9 billion metric tons.

**Substitutes:** Aluminum and plastics substitute for galvanized sheet in automobiles; and aluminum alloy, cadmium, paint, and plastic coatings replace zinc coatings in other applications. Aluminum- and magnesium-based alloys are major competitors for zinc-based die-casting alloys. Many elements are substitutes for zinc in chemical, electronic, and pigment uses.

[e]Estimated. — Zero.
[1]Apparent consumption in 2010 and 2011 does not necessarily reflect reported industry stock changes. Stocks increased during these years owing to an increased response rate from industry.
[2]Platts Metals Week price for North American SHG zinc; based on the LME cash price plus premium.
[3]Includes mine and mill employment at all zinc-producing mines. Source: Mine Safety and Health Administration.
[4]Defined as imports – exports + adjustments for Government and industry stock changes. The net import reliance from 2009 to 2011 does not necessarily reflect reported industry stock changes. Stocks increased during these years owing to an increased response rate from industry.
[5]No tariff for Canada, Mexico, and Peru for items shown.
[6]See Appendix B for definitions.
[7]Zinc content of concentrate and direct shipping ore.
[8]See Appendix C for resource/reserve definitions and information concerning data sources.
[9]For Australia, Joint Ore Reserves Committee (JORC)-compliant reserves were 28.9 million tons.

# ZIRCONIUM AND HAFNIUM

(Data in metric tons unless otherwise noted)

**Domestic Production and Use:** In 2014, three firms mined zircon from surface-mining operations in Florida, Georgia, and Virginia. Zirconium metal and hafnium metal were produced from zirconium chemical intermediates by two domestic producers, one in Oregon and the other in Utah. The zirconium-silicate mineral zircon is produced as a coproduct from the mining and processing of heavy minerals. 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 applications, opacifiers, and refractories are the leading end uses for zircon. Other end uses of zircon include abrasives, chemicals, metal alloys, and welding rod coatings. The leading consumers of zirconium metal and hafnium metal are the nuclear energy and chemical process industries.

| **Salient Statistics—United States:** | 2010 | 2011 | 2012 | 2013 | 2014[e] |
|---|---|---|---|---|---|
| Production, zircon | W | W | W | W | W |
| Imports: | | | | | |
| Zirconium, ores and concentrates ($ZrO_2$ content) | 14,900 | 17,200 | 16,700 | 8,050 | 28,300 |
| Zirconium, unwrought, powder, and waste and scrap | 726 | 487 | 279 | 395 | 805 |
| Zirconium, wrought | 423 | 396 | 288 | 319 | 307 |
| Hafnium, unwrought, powder, and waste and scrap | 6 | 10 | 23 | 10 | 21 |
| Exports: | | | | | |
| Zirconium ores and concentrates ($ZrO_2$ content) | 30,800 | 15,800 | 13,000 | 19,000 | 5,490 |
| Zirconium, unwrought, powder, and waste and scrap | 503 | 677 | 554 | 600 | 640 |
| Zirconium, wrought | 1,530 | 1,330 | 1,250 | 1,140 | 952 |
| Consumption, zirconium ores and concentrates, apparent ($ZrO_2$ content) | W | W | W | W | W |
| Prices: | | | | | |
| Zircon, dollars per metric ton (gross weight): | | | | | |
| Domestic[1] | 860 | 2,650 | 2,650 | 1,050 | 1,050 |
| Imported[2] | 1,093 | 2,122 | 2,533 | 996 | 1,106 |
| Zirconium, unwrought, import, France, dollars per kilogram[3] | 74 | 64 | 91 | 75 | 97 |
| Hafnium, unwrought, import, France, dollars per kilogram[3] | 453 | 544 | 503 | 578 | 568 |
| Net import reliance[4] as a percentage of apparent consumption: | | | | | |
| Zirconium | E | <10% | <10% | E | <20% |
| Hafnium | NA | NA | NA | NA | NA |

**Recycling:** Companies in Oregon and Utah recycled zirconium from scrap generated during metal production and fabrication. Scrap zirconium metal and alloys were recycled by companies in California and Oregon. Zircon foundry mold cores and spent or rejected zirconia refractories are often recycled. Hafnium metal recycling was insignificant.

**Import Sources (2010–13):** Zirconium mineral concentrates: South Africa, 60%; Australia, 35%; and other, 5%. Zirconium, unwrought, including powder: Japan, 49%; Germany, 31%; China, 8%; France, 6%; and other, 6%. Hafnium, unwrought: France, 50%; Australia, 23%; Germany, 21%; and other, 6%.

| **Tariff:** Item | Number | Normal Trade Relations 12–31–14 |
|---|---|---|
| Zirconium ores and concentrates | 2615.10.0000 | Free. |
| Germanium oxides and zirconium dioxide | 2825.60.0000 | 3.7% ad val. |
| 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.

Prepared by **George M. Bedinger [(703) 648–6183, gbedinger@usgs.gov]**

# ZIRCONIUM AND HAFNIUM

**Events, Trends, and Issues:** Domestic production of zirconium ores and concentrates continued at two mines near Stony Creek, VA, and one near Starke, FL. Operations at one of the Virginia mines were idled in April, and the associated mineral separation plant operated at reduced capacity in order to draw down existing inventories. Prices for zircon concentrates were also down from the all-time high prices of 2011 and 2012. U.S. imports increased by about 350% and exports decreased by about 71% owing to reduced domestic production and pent-up demand from the steel refractory and industrial consumers that deferred buying during the period of high prices.

In May, a new zircon mine started up in Charlton County, GA, and a second mine in Brantley County, GA, was expected to begin production in the fourth quarter 2015. A mineral sands plant in Pierce County, GA, was being constructed to process the heavy minerals from the two new mines and was expected to be completed in the second quarter 2015. The operator of the two mines in Virginia announced the decision to mine out deposits at both Virginia operations without further investment and was expected to compete mining and processing activities at these locations at the end of 2015.

Three significant heavy-mineral concentrate projects began production in 2014. In South Africa, the Tormin project began production of zircon and rutile concentrates in January and was expected to produce 48,000 tons per year of nonmagnetic concentrate grading 81% zircon and 11.6% rutile over a 4-year mine life. In Kenya, zircon production at the Kwale project began in February. Production of zircon was expected to be 30,000 tons per year during a mine life of 13 years. In Senegal, production began at the Grande Cote project in March 2014 with the first shipment of zircon made in August. At full production capacity, Grand Cote was expected to produce about 80,000 tons per year of zircon during a mine life of more than 20 years. Heavy-mineral exploration and mining projects were also underway in Australia, Madagascar, Mozambique, Tanzania, and Sri Lanka.

**World Mine Production and Reserves:** World primary hafnium production data are not available. Although hafnium occurs with zirconium in the minerals zircon and baddeleyite, quantitative estimates of hafnium reserves are not available.

| | Zirconium mine production (thousand metric tons) | | Zirconium reserves[5] (thousand metric tons, $ZrO_2$) |
|---|---|---|---|
| | 2013 | 2014[e] | |
| United States | W | W | 500 |
| Australia | 850 | 900 | 51,000 |
| China | 150 | 140 | 500 |
| India | 41 | 40 | 3,400 |
| Indonesia | 110 | 120 | NA |
| Mozambique | 47 | 56 | 1,100 |
| South Africa | 170 | 170 | 14,000 |
| Other countries | 140 | 110 | 7,200 |
| World total (rounded) | [6]1,510 | [6]1,540 | 78,000 |

**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, while 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]Source: Industrial Minerals, yearend average of high-low price range.
[2]Unit value based on U.S. imports for consumption from Australia and South Africa.
[3]Unit value based on U.S. imports for consumption from France.
[4]Defined as imports – exports.
[5]See Appendix C for resource/reserve definitions and information concerning data sources.
[6]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 2014** 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 2014 (fiscal year 2014 is the period October 1, 2013, through September 30, 2014). For mineral commodities that have a disposal plan greater than the inventory, actual quantity will be limited to 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 2014** refers to material sold or traded from the stockpile in FY 2014.

### 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 extraction feasibility 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' supply 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 metric tons of copper. Since then, almost 480 million metric tons of copper have been produced worldwide, but world copper reserves in 2014 were estimated to be 700 million metric tons of copper, more than double those in 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:

**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***

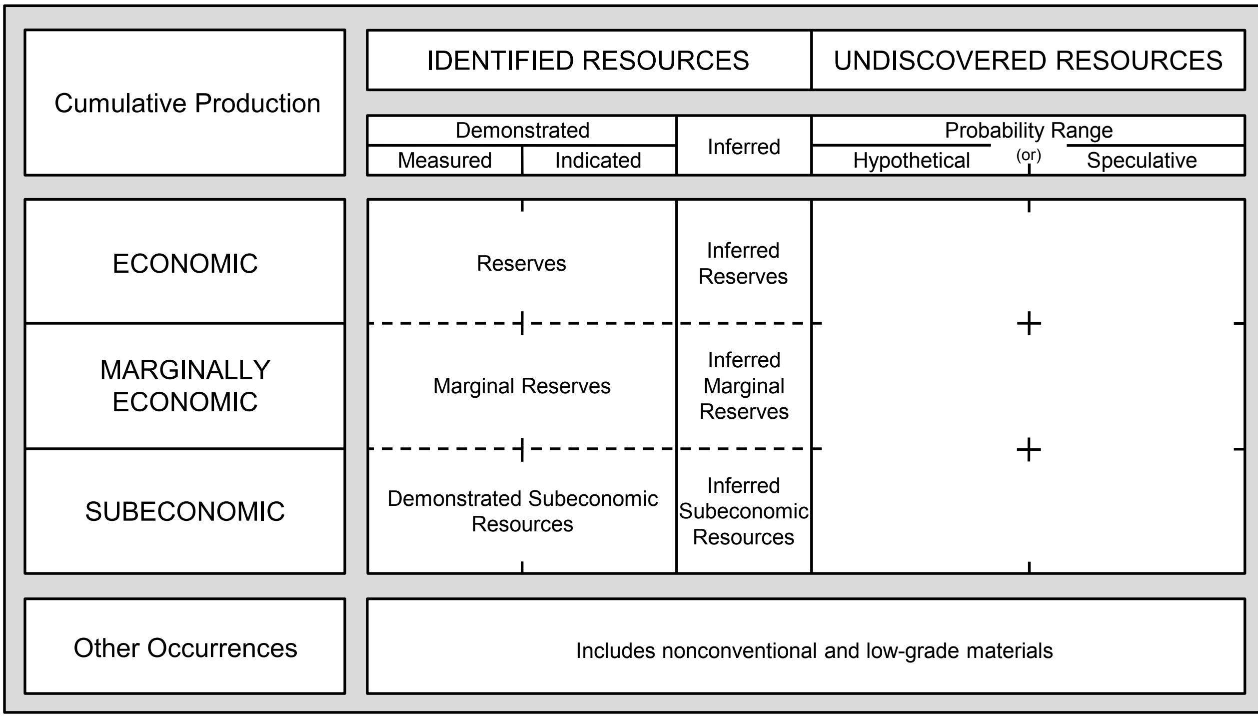
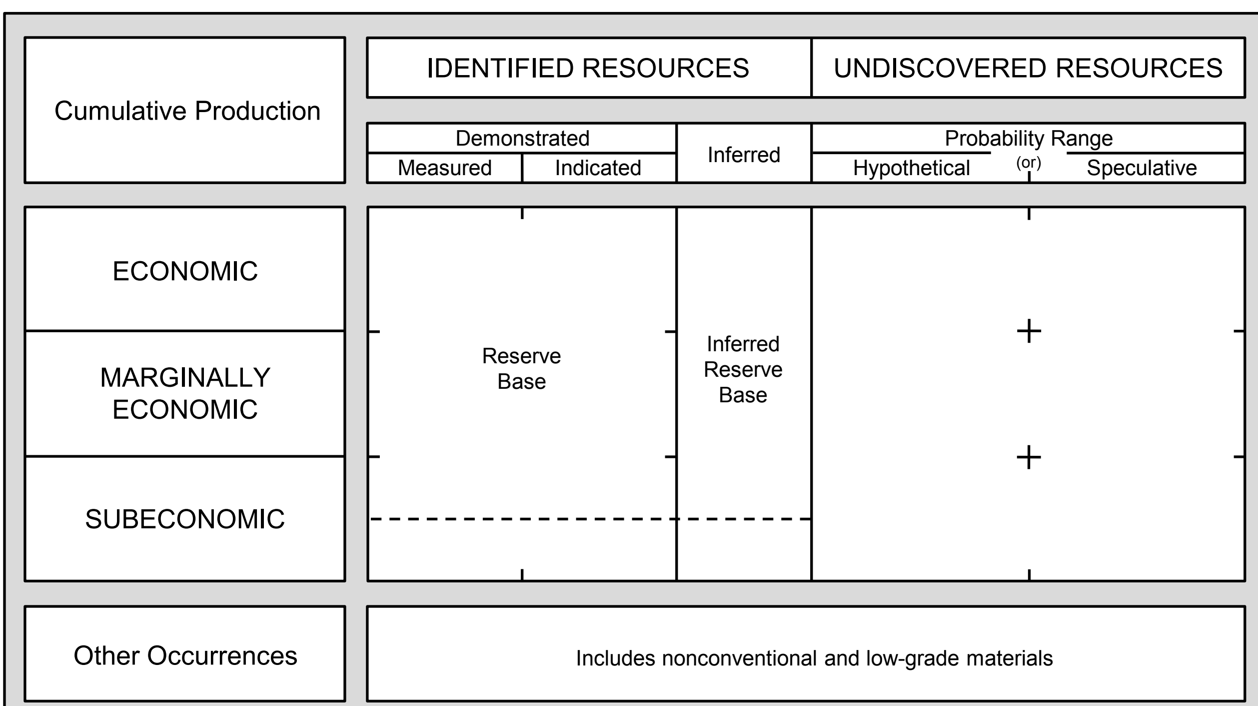



**Figure 2.—*Reserve Base* and *Inferred Reserve Base* Classification Categories**



# Part B—Sources of Reserve 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 reserve 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 reserve 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 reserve 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 reserve 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 2015 are Accessible EDR. For more information, see Australia's Identified Mineral Resources 2013 (http://www.ga.gov.au/corporate_data/78988/78988_AIMR_2013.pdf).

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 reserve 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://www.cim.org/en/News-and-Events/News/2014/CIM-Definition-Standards-and-Guidance-updated.

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 reserve data for various minerals appear at times in journal articles, such as those in the journal Mineral'nye Resursy Rossii [Mineral Resources of Russia (MRR)], which is published by the Russian Ministry of Natural Resources. Russian reserve 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.

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**Africa and the Middle East**

| | |
|---|---|
| Algeria | Mowafa Taib |
| Angola | Omayra Bermúdez-Lugo |
| Bahrain | Waseem Abdulameer |
| Benin | Philip M. Mobbs |
| Botswana | Thomas R. Yager |
| Burkina Faso | Omayra Bermúdez-Lugo |
| Burundi | Thomas R. Yager |
| Cameroon | Philip M. Mobbs |
| Cabo Verde | Philip M. Mobbs |
| Central African Republic | Omayra Bermúdez-Lugo |
| Chad | Philip M. Mobbs |
| Comoros | Philip M. Mobbs |
| Congo (Brazzaville) | Philip M. Mobbs |
| Congo (Kinshasa) | Thomas R. Yager |
| Côte d'Ivoire | Omayra Bermúdez-Lugo |
| Djibouti | Mowafa Taib |
| Egypt | Mowafa Taib |
| Equatorial Guinea | Philip M. Mobbs |
| Eritrea | Thomas R. Yager |
| Ethiopia | Thomas R. Yager |
| Gabon | Waseem Abdulameer |
| The Gambia | Philip M. Mobbs |
| Ghana | Omayra Bermúdez-Lugo |
| Guinea | Omayra Bermúdez-Lugo |
| Guinea-Bissau | Philip M. Mobbs |
| Iran | Philip M. Mobbs |
| Iraq | Waseem Abdulameer |
| Israel | Thomas R. Yager |
| Jordan | Mowafa Taib |
| Kenya | Thomas R. Yager |
| Kuwait | Waseem Abdulameer |
| Lebanon | Mowafa Taib |
| Lesotho | Philip M. Mobbs |
| Liberia | Omayra Bermúdez-Lugo |
| Libya | Mowafa Taib |
| Madagascar | Thomas R. Yager |
| Malawi | Thomas R. Yager |
| Mali | Omayra Bermúdez-Lugo |
| Mauritania | Mowafa Taib |
| Mauritius | Philip M. Mobbs |
| Morocco & Western Sahara | Mowafa Taib |
| Mozambique | Thomas R. Yager |
| Namibia | Omayra Bermúdez-Lugo |
| Niger | Omayra Bermúdez-Lugo |
| Nigeria | Philip M. Mobbs |
| Oman | Waseem Abdulameer |
| Qatar | Waseem Abdulameer |
| Reunion | Philip M. Mobbs |
| Rwanda | Thomas R. Yager |
| São Tomé & Principe | Philip M. Mobbs |
| Saudi Arabia | Waseem Abdulameer |
| Senegal | Omayra Bermúdez-Lugo |
| Seychelles | Philip M. Mobbs |
| Sierra Leone | Omayra Bermúdez-Lugo |
| Somalia | Thomas R. Yager |
| South Africa | Thomas R. Yager |
| South Sudan | Thomas R. Yager |
| Sudan | Mowafa Taib |
| Swaziland | Philip M. Mobbs |
| Syria | Mowafa Taib |
| Tanzania | Thomas R. Yager |
| Togo | Omayra Bermúdez-Lugo |
| Tunisia | Mowafa Taib |
| Uganda | Thomas R. Yager |
| United Arab Emirates | Waseem Abdulameer |
| Yemen | Waseem Abdulameer |
| Zambia | Philip M. Mobbs |
| Zimbabwe | Philip M. Mobbs |

**Asia and the Pacific**

| | |
|---|---|
| Afghanistan | Karine Renaud |
| Australia | Pui-Kwan Tse |
| Bangladesh | Yolanda Fong-Sam |
| Bhutan | Yolanda Fong-Sam |
| Brunei | Pui-Kwan Tse |
| Burma (Myanmar) | Yolanda Fong-Sam |
| Cambodia | Yolanda Fong-Sam |
| China | Pui-Kwan Tse |
| East Timor | Pui-Kwan Tse |
| Fiji | Lin Shi |
| India | Karine Renaud |
| Indonesia | Susan Wacaster |
| Japan | Susan Wacaster |
| Korea, North | Susan Wacaster |
| Korea, Republic of | Susan Wacaster |
| Laos | Yolanda Fong-Sam |
| Malaysia | Pui-Kwan Tse |
| Mongolia | Lin Shi |
| Nauru | Pui-Kwan Tse |
| Nepal | Yolanda Fong-Sam |
| New Caledonia | Susan Wacaster |
| New Zealand | Pui-Kwan Tse |
| Pakistan | Karine Renaud |
| Papua New Guinea | Susan Wacaster |
| Philippines | Yolanda Fong-Sam |
| Singapore | Pui-Kwan Tse |
| Solomon Islands | Karine Renaud |
| Sri Lanka | Karine Renaud |
| Taiwan | Pui-Kwan Tse |
| Thailand | Yolanda Fong-Sam |
| Vietnam | Yolanda Fong-Sam |

**Europe and Central Eurasia**

| | |
|---|---|
| Albania | Sinan Hastorun |
| Armenia[1] | Elena Safirova |
| Austria[2] | Sinan Hastorun |
| Azerbaijan[1] | Elena Safirova |
| Belarus[1] | Elena Safirova |
| Belgium[2] | Alberto A. Perez |
| Bosnia and Herzegovina | Sean Xun |

**Europe and Central Eurasia—continued**

| | |
|---|---|
| Bulgaria[2] | Sean Xun |
| Croatia[2] | Sinan Hastorun |
| Cyprus[2] | Sinan Hastorun |
| Czech Republic[2] | Sean Xun |
| Denmark, Faroe Islands, and Greenland[2] | Alberto A. Perez |
| Estonia[2] | Lin Shi |
| Finland[2] | Alberto A. Perez |
| France[2] | Alberto A. Perez |
| Georgia | Elena Safirova |
| Germany[2] | Alberto A. Perez |
| Greece[2] | Lin Shi |
| Hungary[2] | Sinan Hastorun |
| Iceland | Alberto A. Perez |
| Ireland[2] | Alberto A. Perez |
| Italy[2] | Alberto A. Perez |
| Kazakhstan[1] | Elena Safirova |
| Kosovo | Sinan Hastorun |
| Kyrgyzstan[1] | Karine Renaud |
| Latvia[2] | Lin Shi |
| Lithuania[2] | Lin Shi |
| Luxembourg[2] | Alberto A. Perez |
| Macedonia | Sean Xun |
| Malta[2] | Sinan Hastorun |
| Moldova[1] | Elena Safirova |
| Montenegro | Sinan Hastorun |
| Netherlands[2] | Alberto A. Perez |
| Norway | Alberto A. Perez |
| Poland[2] | Sean Xun |
| Portugal[2] | Sean Xun |
| Romania[2] | Sean Xun |
| Russia[1] | Elena Safirova |
| Serbia | Sean Xun |
| Slovakia[2] | Lin Shi |
| Slovenia[2] | Sean Xun |
| Spain[2] | Yadira Soto-Viruet |
| Sweden[2] | Alberto A. Perez |
| Switzerland | Sinan Hastorun |
| Tajikistan[1] | Karine Renaud |
| Turkey | Sinan Hastorun |
| Turkmenistan[1] | Karine Renaud |
| Ukraine[1] | Elena Safirova |
| United Kingdom[2] | Alberto A. Perez |
| Uzbekistan[1] | Elena Safirova |

**North America, Central America, and the Caribbean**

| | |
|---|---|
| Aruba | Yadira Soto-Viruet |
| Belize | Susan Wacaster |
| Bermuda | Yadira Soto-Viruet |
| Canada | Philip M. Mobbs |
| Costa Rica | Susan Wacaster |
| Cuba | Yadira Soto-Viruet |
| Dominican Republic | Yadira Soto-Viruet |
| El Salvador | Susan Wacaster |
| Guatemala | Susan Wacaster |
| Haiti | Yadira Soto-Viruet |
| Honduras | Susan Wacaster |
| Jamaica | Yadira Soto-Viruet |
| Mexico | Yadira Soto-Viruet |
| Nicaragua | Susan Wacaster |
| Panama | Susan Wacaster |
| Trinidad and Tobago | Yadira Soto-Viruet |

**South America**

| | |
|---|---|
| Argentina | Susan Wacaster |
| Bolivia | Susan Wacaster |
| Brazil | Yadira Soto-Viruet |
| Chile | Susan Wacaster |
| Colombia | Susan Wacaster |
| Ecuador | Susan Wacaster |
| French Guiana | Philip M. Mobbs |
| Guyana | Philip M. Mobbs |
| Paraguay | Yadira Soto-Viruet |
| Peru | Yadira Soto-Viruet |
| Suriname | Philip M. Mobbs |
| Uruguay | Yadira Soto-Viruet |
| Venezuela | Yadira Soto-Viruet |

[1]Member of Commonwealth of Independent States.
[2]Member of European Union.

| Country specialist | Telephone | E-mail |
|---|---|---|
| Waseem Abdulameer | (703) 648-7747 | wabdulameer@usgs.gov |
| Omayra Bermúdez-Lugo | (703) 648–4946 | obermude@usgs.gov |
| Yolanda Fong-Sam | (703) 648–7756 | yfong-sam@usgs.gov |
| Sinan Hastorun | (703) 648–7744 | shastorun@usgs.gov |
| Philip M. Mobbs | (703) 648–7740 | pmobbs@usgs.gov |
| Alberto A. Perez | (703) 648–7749 | aperez@usgs.gov |
| Karine Renaud | (703) 648--7748 | krenaud@usgs.gov |
| Elena Safirova | (703) 648–7731 | esafirova@usgs.gov |
| Lin Shi | (703) 648–7994 | lshi@usgs.gov |
| Yadira Soto-Viruet | (703) 648–4957 | ysoto-viruet@usgs.gov |
| Mowafa Taib | (703) 648–4986 | mtaib@usgs.gov |
| Pui-Kwan Tse | (703) 648–7750 | ptse@usgs.gov |
| Susan Wacaster | (703) 648–7785 | swacaster@usgs.gov |
| Sean Xun | (703) 648--7746 | sxun@usgs.gov |
| Thomas R. Yager | (703) 648–7739 | tyager@usgs.gov |