



2016 Minerals Yearbook

GARNET, INDUSTRIAL [ADVANCE RELEASE]

GARNET, INDUSTRIAL

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In 2016, U.S. production of crude garnet concentrate for industrial use was estimated to be 56,400 metric tons (t) valued at about \$12.8 million, a slight increase in tonnage and virtually unchanged in value from 55,200 t valued at \$12.7 million in 2015. U.S. production of refined garnet in 2016 was estimated to be 49,400 t valued at \$24.4 million, a slight increase in tonnage and a slight decrease in value from 48,700 t valued at \$24.8 million in 2015. U.S. exports of industrial garnet were 13,400 t, a 9% decrease compared with those in 2015. Imports of garnet were estimated to be 150,000 t in 2016, a 38% decrease compared with those in 2015. These imports accounted for about 78% of U.S. apparent consumption of 193,000 t. World crude production was estimated to be 1.2 million metric tons (Mt) in 2016, essentially unchanged compared with that in 2015 (table 1).

Garnet is the general name given to a group of complex silicate minerals with similar properties and chemical composition. The general chemical formula for garnet minerals is $A_3B_2(SiO_4)_3$, where A can be calcium, ferrous iron, magnesium, or manganese, and B can be aluminum, chromium, ferric iron, or rarely, titanium. The most common garnet minerals are classified into three groups—the aluminum-garnet group, the chromium-garnet group, and the iron-garnet group. The most common minerals of the aluminum-garnet group are almandine, grossular, pyrope, and spessartine. Uvarovite is the most common chromium-garnet mineral, and andradite is the most common iron-garnet mineral. Garnet occurs worldwide in many rock types, principally gneisses and schists; other sources include contact metamorphic rocks, metamorphosed crystalline limestones, pegmatites, and serpentinites. Alluvial garnet is associated with heavy-mineral-sand and -gravel deposits in many parts of the world. Occurrences of garnet are numerous, but relatively few commercially viable garnet deposits have been identified.

Garnet has many industrial applications because of its angular fractures, relatively high hardness and specific gravity, chemical inertness, nontoxicity, lack of crystalline silica, and ability to be recycled. The primary industrial applications of garnet were, in decreasing percentage of consumption, for abrasive blasting, water-jet cutting, water filtration media, and abrasive powders.

This chapter includes information on garnet produced in the United States that was used for industrial purposes. Current information on gem-grade garnet can be found in the U.S. Geological Survey (USGS) Minerals Yearbook, volume I, Metals and Minerals, chapter on gemstones.

Production

A few major companies dominate the production of industrial garnet in the United States. The garnet industry has encountered progressively higher production costs and tighter profit margins during the past 20 years, resulting in the loss of noncompetitive producers. Because of the need to keep costs at a minimum, the most competitive companies are those that produce garnet in

combination with one or two other minerals, have reserves that can be mined at a low cost, and have the ability to react rapidly to changes in market demand. The value of industrial garnet is influenced by the size and grade of reserves, the type and quality of garnet mined, the proximity of deposits to infrastructure and consumers, and the milling costs. The majority of industrial-grade garnet mined in the United States consists of almandine (iron-aluminum silicate) and pyrope (magnesium-aluminum silicate), although some andradite (calcium-iron silicate) also is mined domestically. Industrial garnet is produced from alluvial bar and beach deposits, such as those in Idaho and Montana (also those in Australia and India), and from hard-rock deposits, such as those in New York (Moore, 2006).

In the United States, four companies mined garnet in three States during 2016. Three were vertically integrated garnet mining and processing companies—Barton International in Warren County, NY; Emerald Creek Garnet Ltd. in Benewah County, ID; and Garnet USA LLC in Madison County, MT. One producer, NYCO Minerals Inc. (a subsidiary of Imerys, S.A., France) in Essex County, NY, produced garnet as a byproduct of wollastonite mining and sold the material to processors. The USGS estimated the production quantities and values by using industry sources, industry production trends, and past reports from producers adjusted by employment data from the Mine Safety and Health Administration.

In 2016, U.S. production of crude garnet concentrate for industrial use was estimated to have increased slightly to 56,400 t from 55,200 t in 2015, and the estimated value was essentially unchanged at \$12.8 million free on board (f.o.b.) mine site. The United States accounted for about 5% of global industrial garnet production. Refined garnet production was estimated to be 49,400 t valued at \$24.4 million f.o.b. plant site compared with 48,700 t valued at \$24.8 million in 2015. Industrial garnet's retail value is dependent on type, source, quality, and degree of processing.

Emerald Creek Garnet (a subsidiary of Opta Minerals Inc.) mined alluvial almandine garnet in Idaho by excavating floodplain sediments and using a specialized shaker and jig system to sort the garnet. In 2016, the company received a 10-year extension of the original 1994 U.S. Army Corps of Engineers dredge and fill permit authorized under Section 404 of the Clean Water Act. Emerald Creek Garnet was granted permission to remine the West Fork Emerald Creek watershed and was required to perform some wetlands restoration (Idaho Department of Environmental Quality, 2016, p. 1). Opta Minerals was privatized in 2016 after being purchased by Speyside Equity Fund I LP (Speyside Equity LLC, 2016).

Garnet USA (a subsidiary of GMA Garnet Pty Ltd.) continued ramping up production of almandine garnet at its new quarry in southwestern Montana. Garnet USA also upgraded its processing plant at Alder Gulch, MT, and received a new air

quality permit in 2016 that would allow production of up to 100,000 metric tons per year of garnet (Montana Department of Environmental Quality, 2016).

In New York, Barton International continued mining an almandine-pyrope mixture from a quarry at Ruby Mountain. NYCO Minerals produced andradite garnet as a byproduct from its wollastonite mining operation; the garnet was sold as part of a waste stream and some was processed by International Garnet Abrasive Inc. (an Opta Minerals company) in Keesville, NY. In 2016, the mining operation shifted to Oak Hill, NY, because of economic considerations. NYCO was awaiting a mining permit modification that would extend the life of its Willsboro mine by 3 years (Dedam, 2016).

In New Mexico, Burrell Resources Group, LLC suspended development of a garnet mine in Otero County that was originally expected to begin operating in 2016. The company, which had been seeking economic development funding for the mining and processing operation, declined a \$750,000 grant from the New Mexico Economic Development Department to help build the processing plant. Burrell cited a slowdown in the oil and gas industry, an associated decline in garnet demand and prices, and logistical issues as the reasons for declining the grant (Krasnow, 2017).

Consumption

U.S. apparent consumption, defined as crude production plus imports minus exports, decreased by 31% to an estimated 193,000 t in 2016 from 280,000 t in 2015 owing to a large decrease in imports (table 1). The major end uses for garnet in the United States in 2016 were estimated to be abrasive blasting (50%), water-jet cutting (30%), and water filtration media (15%), with the remainder used as abrasive powders, as an additive in nonslip coatings, in sandpaper, or other uses. Domestic industries that consume garnet include aircraft and motor vehicle manufacturers, ceramics and glass producers, electronic component manufacturers, glass polishing, the petroleum industry, shipbuilding and maintenance, structural steel fabrication and maintenance, textile stonewashing, water filtration plants, and wood-furniture-finishing operations.

Most industrial garnet is used as an abrasive because of its hardness, which ranges from 6 to 7.5 on the Mohs scale. High-quality, high-value garnet grain has been used principally for such applications as optical lens grinding and plate-glass grinding for more than a century; industrial diamond and fused aluminum oxide are competitors in these applications. In recent years, industrial garnet powders have been used for high-quality, scratch-free lapping of semiconductor materials and other metals. Garnet is a good alternative to silica sand as a natural abrasive blasting media because it does not have the health risks associated with the inhalation of airborne crystalline silica dust, and it is a safer abrasive for the environment (Lismore, 2013). Garnet has replaced some silica sand in the abrasive blasting media market, but at present, silica sand and mineral slag continue to be the most widely used media in blasting.

The U.S. oil and gas drilling industry is one of the leading garnet-consuming industries, using garnet for cleaning drill pipes and well casings. Oil and gas producers also use garnet as reservoir-fracturing proppant, alone or mixed with other

proppants. The decrease in garnet consumption compared with that in 2015 was likely a result of decreased drilling activity in the petroleum industry. During 2016, the number of drill rigs operating in the United States was 664 rigs at the beginning of the year and 658 rigs at the end of the year. However, the rig count was lower during much of the year, declining to 404 rigs in May. The average weekly drill rig count for 2016 was 509 operating rigs, compared with an average of 978 in 2015 (Baker Hughes Inc., 2017).

The aircraft manufacturing and shipbuilding industries use garnet for blast cleaning and for finishing metal surfaces. Similar uses include the cleaning and conditioning of aluminum and other soft metals, as well as metal cleaning by structural steel fabrication shops. Garnet entrained in high-pressure streams of water also is used to cut many different materials. Garnet powders are used for antiskid surfaces, antislip paints, and glass and ceramic polishes.

Water-jet cutting is the process of combining water under ultrahigh pressure with entrained garnet grains to cut a wide variety of materials. Materials cut using this process range from soft leather and fabric to hard steel, titanium, and other metals. Water-jet cutting makes it possible to carve extremely complex shapes with computer-assisted cutter control. Almandine-pyrope garnet is excellent for this application because it strikes the necessary balance between cutting productivity and equipment wear. The water-jet market began to develop slowly in the late 1980s and early 1990s, and it has grown at a faster rate in the past 20 years. Future growth is expected to remain steady as use of this technology expands in existing areas and enters new applications. Two-dimensional water-jet tables have been produced in larger standard sizes in recent years, up to 4 by 14 meters, and the ability to cut three-dimensional shapes using accessories and special software has become available for some models (Olsen, 2012a, b). Abrasive water-jet cutting provides a tool for manufacturers faced with the task of cutting new materials, such as composites and sandwiched materials that had been problematic to machine in the past. Water-jet cutting allows for flexibility and eliminates the need for flame cutting. Cutting fragile materials or intricate patterns by abrasive water-jet cutting significantly decreases the amount of distortion and breakage (Rapple, 2006). Garnet materials most preferred for water-jet cutting applications remained in tight supply.

Low-quality industrial garnet, which has lower hardness and is more highly fractured, is used as a high-density medium in water filtration systems because of its relative inertness and resistance to chemical degradation. Garnet is well suited for water filtration and treatment because it is relatively heavy and chemically stable. Mixed-media water filtration, which uses a mixture of anthracite, garnet, and silica sand, has displaced older filtration methods because it provides better water quality. Garnet competes with ilmenite, magnetite, plastics, and silica sand as a filtration medium.

Prices

Industrial garnet pricing varies over a wide range, depending on application, quality, quantity purchased, source, and type. During 2016, estimated domestic unit values for crude garnet concentrates ranged from about \$175 to \$275 per metric ton, with

an average for the year of \$227 per ton; this was a slight decrease from the 2015 average of \$230 per ton. Domestic unit values for refined garnet sold during the year ranged from \$200 to \$540 per ton, with an average for the year of \$493 per ton; this was a 3% decrease from the 2015 average of \$509 per ton.

The estimated average unit values of garnet from other leading producers around the world based on the customs value of import shipments were as follows: China, \$300 per ton; Australia, \$200 per ton; and India, \$190 per ton. During 2016, the average unit value of industrial garnet imported from all sources was \$200 per ton of crude garnet, a decrease from \$230 per ton in 2015.

Foreign Trade

Exports of industrial garnet in 2016 were 13,400 t, and imports were estimated to be 150,000 t. Exports decreased by 9% from those of 2015, and imports decreased by 38%. In 2016, Australia (47%), India (47%), and China (5%) supplied the majority of United States garnet imports for consumption, with Canada and 10 other countries providing the remaining 1% of imports. Garnet exports from the United States were shipped primarily to Canada (30%), Mexico (25%), Trinidad and Tobago (7%), China (7%), and The Bahamas (5%), with the remainder going to many other countries.

World Review

Total world industrial garnet production was estimated to be about 1.2 Mt in 2016, essentially unchanged from that in 2015. The leading global producers were Australia, 580,000 t; South Africa, 270,000 t; India, 200,000 t; China, 89,000 t; the United States, 56,400 t; and other countries, 50,000 t.

In India, the Ministry of Mines and the State of Tamil Nadu launched surveillance systems to identify illegal mining operations and shut them down (Ravishankar, 2017). India's garnet production was expected to decrease during the coming years owing to the crackdown on illegal mining and exports.

Russia and Turkey have been mining garnet in recent years, and small garnet-mining operations also are located in Canada, Chile, Czechia, Pakistan, South Africa, Spain, Thailand, and Ukraine, but the available information was insufficient to make reliable estimates of output. Production in most of these countries is for domestic use.

Outlook

The U.S. garnet industry has had higher production costs and tighter profit margins during recent years. The industry also has been competing with lower priced foreign imports, which have displaced U.S. production in domestic markets, resulting in the closure of noncompetitive operations.

Garnet is likely to continue displacing silica sand for blasting as countries ban the use of silica sand blasting media owing to concerns about potential occupational health risks. Garnet also is expected to continue displacing mineral slag abrasives for blasting because it is safer for the environment and less costly to dispose of after it has been recycled (Lismore, 2013).

Worldwide demand for industrial garnet is expected to continue to increase, especially within the markets for abrasive

grains for water-jet cutting and for abrasive blasting media. Garnet demand also is expected to continue to expand for aircraft manufacturing and shipbuilding, where significant quantities of garnet are used for abrasive blast cleaning and finishing of metal surfaces and for water-jet cutting.

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TABLE 1
SALIENT INDUSTRIAL GARNET STATISTICS¹

		2012	2013	2014	2015	2016
United States:						
Crude production:						
Quantity	metric tons	40,300 ^r	50,600 ^r	42,100 ^r	55,200 ^r	56,400
Value	thousands	\$9,860 ^r	\$12,600 ^r	\$9,350 ^r	\$12,700 ^r	\$12,800
Refined garnet production:						
Quantity	metric tons	36,300 ^r	45,500 ^r	37,100 ^r	48,700 ^r	49,400
Value	thousands	\$19,400 ^r	\$26,400 ^r	\$17,300 ^r	\$24,800 ^r	\$24,400
Exports: ²						
Quantity	metric tons	14,600	14,400	15,400	14,700	13,400
Value	thousands	\$14,700	\$16,000	\$12,800	\$11,000	\$10,800
Imports for consumption: ^{3,3}						
Quantity	metric tons	170,000 ^r	150,000 ^r	210,000 ^r	240,000 ^r	150,000
Value	thousands	\$35,000 ^r	\$34,000	\$45,000 ^r	\$54,000 ^r	\$30,000
Apparent consumption: ^{3,4}						
Quantity	metric tons	196,000 ^r	186,000 ^r	237,000 ^r	280,000 ^r	193,000
Value	thousands	\$30,200 ^r	\$30,600 ^r	\$41,600 ^r	\$55,700 ^r	\$32,000
World, crude production	metric tons	1,790,000 ^r	1,450,000 ^r	1,210,000 ^r	1,180,000 ^r	1,200,000

^rEstimated. ^rRevised.

¹Table includes data available through April 5, 2018. Data are rounded to no more than three significant digits.

²Source: U.S. Census Bureau.

³Source: U.S. Census Bureau; adjusted by U.S. Geological Survey; rounded to two significant digits.

⁴Domestic production plus imports minus exports.