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GARNET, INDUSTRIAL

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By Donald W. Olson

Domestic survey data and table were prepared by Connie Lopez, statistical assistant.

In 2012, U.S. production of crude garnet concentrate for industrial use was estimated to be 46,900 metric tons (t) valued at about $8.60 million, a decrease from 56,400 t valued at about $9.76 million in 2011. U.S. exports and imports of industrial garnet were estimated to be 14,600 t and 166,000 t, respectively. U.S. apparent consumption was estimated to be 199,000 t. World production of crude garnet concentrate for industrial use was estimated to be 1.67 million metric tons (Mt) during 2012, compared with 1.66 Mt in 2011 (table 1).

This report 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. Trade data in this report are from the U.S. Census Bureau. All percentages in the report were computed using unrounded data.

Garnets have been used as gemstones and abrasives for centuries. Garnet necklaces have been found in burial sites as far back as the Bronze Age (3600 to 600 B.C.), and garnet is found among the ornaments adorning the oldest Egyptian mummies. Garnet is ideal for many industrial applications because of its angular fractures, relatively high hardness and specific gravity, chemical inertness, nontoxicity, lack of crystalline silica, and its ability to be recycled.

Garnet is the general name given to a group of complex silicate minerals, all with isometric crystal structure and similar properties and chemical composition. The general chemical formula for the 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 or almandite, grossularite, pyrope, and spessartite.

Andradite is the most common iron-garnet mineral, and uvarovite is the most common chromium garnet. 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; however, relatively few commercially viable garnet deposits have been identified.

Production

The U.S. industrial garnet industry is dominated by a few major producers. The garnet industry has encountered progressively higher production costs and tighter profit margins since the mid-1990s. These factors have resulted in the loss of noncompetitive producers. Because of the need to keep production costs at a minimum, the most competitive producers are those who 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 is almandine (iron aluminum silicate) and pyrope (magnesium aluminum silicate); some andradite (calcium iron silicate) also is mined domestically. Industrial garnet is produced from alluvial bar and beach deposits, like those in Idaho and Montana (also those in Australia and India), and it is produced from hard rock deposits, like those in New York (Moore, 2006).

Four U.S. companies accounted for all domestic production—one in Idaho, one in Montana, and two in New York. The USGS obtained the data in this report through a survey of U.S. industrial garnet producers. Two of the four domestic producers reported their output and sales to the USGS, and production amounts and values for the nonreporting companies were estimated based on industry production trends, reports from some producers and other industry sources, and discussions with consultants within the garnet industry.

In 2012, U.S. production of crude garnet concentrate for industrial use was estimated to be 46,900 t valued at about $8.60 million (table 1). This was a 17% decrease in production quantity and a decrease of 12% in value compared with 56,400 t valued at $9.76 million in 2011. The United States accounted for about 3% of global industrial garnet production. Refined garnet material produced during 2012 was estimated to be 25,800 t valued at $7.08 million, a unit value of $275 per metric ton, which was a 23% decrease in quantity, a decrease of about 27% in total value, and a 4% decrease in unit value compared with the 2011 levels. Garnet producers in 2012 were Barton International in Warren County, NY; Emerald Creek Garnet Ltd. in Benewah County, ID; NYCO Minerals, Inc. in Essex County, NY; and Ruby Valley Garnet LLC in Madison County, MT. In addition to the producers cited above, Opta Minerals Inc. in Clinton County, NY, processed and sold all the crude garnet mined by NYCO Minerals as a byproduct of wollastonite production in 2012.

On August 29, 2012, Opta Minerals Inc. acquired WGI Heavy Minerals, Inc. by the purchase of 94% of the outstanding common shares of WGI Heavy Minerals and the planned compulsory acquisition transaction of remaining shares. WGI Heavy Minerals was the parent company of Emerald Creek Garnet which mined garnet in the Carpenter and Emerald Creek basins in Idaho. WGI Heavy Minerals, through its subsidiaries, markets and sells abrasive products and services and waterjet replacement parts globally (Opta Minerals Inc., 2012; Patel,

2012). International Garnet Abrasive Inc., which was acquired by Opta Minerals Inc. in 2001, changed its name to Opta Minerals Inc. in 2012.

A new mining operation being developed in Coos County, OR, by Oregon Resources Corp. was expected to produce alluvial sands containing chromite, spessartite garnet, and other minerals. The company planned to process a test run of garnet production in August 2012 for evaluation. During the last quarter of 2012, and continuing into 2013, the garnet operation was placed under care-and-maintenance status. Once the garnet production is brought online, the garnet is intended for waterjet cutting markets (Brianna Hanson, director of marketing and sales, Oregon Resources Corp., oral commun., July 30, 2012; May 8, 2013). Oregon Resources estimated that the mine will produce 635,000 tons per year of ore, yielding 54,400 t of chromite and 16,300 to 18,100 t of spessartite garnet. Oregon Resources projected a 15-year mine life for the operation (James Dingman, retired director of marketing and sales, Oregon Resources Corp., written commun., February 28, 2007; oral commun., July 27, 2012).

Consumption

In 2012, the estimated U.S. apparent consumption of industrial garnet was 199,000 t. This was a 26% increase compared with the U.S. apparent consumption quantity of 2011. The United States accounted for about 12% of global industrial garnet use.

The end uses for garnet in the United States and their estimated market share in 2012 were abrasive grains for waterjet cutting, 35%; abrasive blasting media, 30%; water filtration, 20%; abrasive powders, 10%; and other, 5%. Domestic industries that consume garnet include aircraft and motor vehicle manufacturers, ceramics and glass producers, electronic component manufacturers, filtration plants, glass polishing, the petroleum industry, shipbuilders, textile stonewashing, and wood-furniture-finishing operations.

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 has replaced some silica sand in the abrasive blasting media market because garnet does not have the health risks associated with the inhalation of airborne crystalline silica dust. At present, however, silica sand and mineral slag continue to be the most widely used media in blasting. The U.S. petroleum industry is one of the leading garnet-consuming industries, using garnet for cleaning drill pipes and well casings.

Garnet is also beginning to be used as an oil and gas reservoir fracturing proppant or mixed with other proppants. In August, Preferred Sands, LLC., one of North America's leading hydraulic fracturing sand and coated proppant manufacturers, introduced a nonphenolic coated proppant that can consistently create particle-to-particle bonding in conditions as low as 32 °C (90 °F) without the use of an activator. This proprietary technology was developed by Preferred Sands in conjunction with The Dow Chemical Co. The new proppant, RCS Garnet, can be used in low-temperature well environments, such as those found in Alberta, Canada, and in the Permian Basin in Texas. RCS Garnet is an alternative to commonly used phenolic products, which were designed for use in high-temperature environments and require an activator to create the particle-to-particle bonding necessary for flowback control in low-temperature wells. Using an activator adds cost and risk of contamination. RCS Garnet was designed to create particle-to-particle bonding between 32 °C (90 °F) and 93 °C (200 °F) without the use of an activator. RCS Garnet was launched and went into full production in February 2013. RCS Garnet minimizes chemical leaching, reduces environmental impacts, and improves performance and sustainability (PR Newswire, 2012; Dow Chemical Co., 2013).

The aluminum 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 generally are used for antiskid surfaces, antislip paints, and glass and ceramic polishes.

Waterjet 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. Waterjet cutting makes it possible to carve extremely complex shapes with computer-assisted cutter control. Almandine–pyrope garnet is excellent for this application as it strikes the necessary balance between cutting productivity and equipment wear. The waterjet 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. Abrasive waterjet 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. Waterjet cutting allows for flexibility and eliminates the need for flame cutting. Cutting fragile materials or intricate patterns by abrasive waterjet cutting significantly decreases the amount of distortion or breakage (Rapple, 2006).

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.

Other applications for garnet include the manufacture of coated abrasives and the finishing of felt, hard rubber, leather, plastics, and wood. In the coated-abrasive market, garnet falls

between low-cost quartz sand or staurolite and more costly manufactured abrasives, such as fused alumina and silicon carbide. Garnet is more efficient than quartz sand in most coated-abrasive applications. Owing to its friable nature and lower hardness, garnet cannot compete with manufactured abrasives in metalworking applications that require substantial metal removal.

U.S. industrial garnet apparent consumption has increased steadily since 2009 and in 2012, exceeded levels seen prior to the global recession. The industrial garnet market also has recovered. Garnet materials most preferred for waterjet cutting applications remain in tight supply.

Prices

Industrial garnet is priced at a wide range, depending on application, quality, quantity purchased, source, and type. During 2012, domestic values for crude concentrates for different applications ranged from about $94 to $208 per metric ton, with an average for the year of $183 per ton. Domestic values for refined garnet for different applications sold during the year ranged from $215 to $331 per ton, with an average for the year of $275 per ton.

The estimated average values of garnet from other leading producers around the world based on the customs value of import shipments were as follows: Australia, $193 per ton; Canada, $228 per ton; China, $453 per ton; and India, $187 per ton. During 2012, the average value of industrial garnet imported from all sources was $208 per ton, which was a slight decrease from $211 per ton in 2011.

Foreign Trade

Lower priced foreign imports of garnet slowly began displacing U.S. production in domestic markets during the 1990s. For the past 5 years, industrial garnet imports have provided between 59% and 78% of the total U.S. industrial garnet supply.

The U.S. Census Bureau compiles trade data on exports and imports of industrial garnet mixed with other natural abrasive commodities, such as emery and corundum, so the data cannot be identified specifically as garnet. Exports and imports of industrial garnet for 2012 were estimated to be 14,600 t and 166,000 t, respectively. These estimates were based on reports from some producers and other industry sources, and discussions with garnet industry consultants. Exports increased slightly from those of 2011, and imports increased by about 44% compared with those of 2011. In 2012, Australia, China, and India continued to supply the majority of the U.S. garnet imports for consumption, with Australia providing 54%; India, 39%; China, 5%; and other countries, 2%. About 79% of garnet exports from the United States went to Brazil, Canada, China, Germany, Mexico, Sweden, Taiwan, Trinidad and Tobago, and the United Kingdom.

World Review

The USGS estimated total 2012 world industrial garnet production to be about 1.67 Mt, a very slight increase compared with that in 2011. In 2012, India, China, Australia, and the United States were, in decreasing tonnage order, the leading producers. In 2012, India produced about 48% of total global production; China, about 31%; Australia, 16%; the United States, about 3%; and other countries, about 2%. China and India are expected to continue as the leading world producers of industrial garnet. Russia and Turkey have been mining garnet in recent years, primarily for domestic markets. Small garnet-mining operations also are located in Canada, Chile, the Czech Republic, Pakistan, South Africa, Spain, Thailand, and Ukraine. Production in most of these countries is for domestic use.

Industrial garnet suppliers in Australia and India continued to be negatively affected by stronger domestic currencies against the U.S. dollar and increased production costs. This allowed supply replacement from lower priced sources in China. The Chinese supply of industrial garnet was increasing, but the quality of those supplies has not been as consistent as other producers (Industrial Minerals, 2011).

China and India were expected to steadily increase garnet output for the next decade and have become significant garnet sources for other countries. Worldwide end uses and their estimated market shares were abrasive blasting media, 50%; abrasive grains for waterjet cutting, 30%; water filtration, 15%; and other end uses, 5%.

Outlook

The U.S. garnet industry has encountered higher production costs and tighter profit margins during recent years. The industry also has been competing with lower priced foreign imports that have displaced U.S. production in domestic markets, so much so that, for the past 7 years, industrial garnet imports have exceeded domestic industrial garnet production. This has resulted in the closure of noncompetitive operations. Because of the need to keep production costs at a minimum, the most competitive producers are those who 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. An example of a new mining operation that will produce more than one mineral is the mine being developed in Coos County, OR, by Oregon Resources Corp. The mine was expected to produce chromite, spessartite garnet, zircon, and ilmenite (James Dingman, retired director of marketing and sales, Oregon Resources Corp., written commun., February 28, 2007; oral commun., July 27, 2012).

Worldwide demand for industrial garnet is expected to continue to increase, especially within the markets for abrasive grains for waterjet 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 waterjet cutting. The use of garnet in waterjet cutting is expected to increase at a higher rate than the use of garnet as an abrasive blasting media.

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TABLE 1
ESTIMATED SALIENT U.S. INDUSTRIAL GARNET STATISTICS[1]

		2008	2009	2010	2011	2012
United States:						
Crude production:						
Quantity	metric tons	62,900	45,600	52,600	56,400	46,900
Value	thousands	$13,600	$6,850	$7,910	$9,760	$8,600
Refined garnet production:						
Quantity	metric tons	49,800	22,100	28,900	33,700	25,800
Value	thousands	$13,500	$6,100	$7,510	$9,660	$7,080
Exports:						
Quantity	metric tons	12,500	13,200	11,700	14,500	14,600
Value	thousands	$9,050	$10,700	$14,400	$14,100	$14,600
Imports for consumption:						
Quantity	metric tons	92,300	71,100	79,700	116,000	166,000
Value	thousands	$21,700	$16,700	$20,800	$24,500	$34,500
Apparent consumption[2]	metric tons	143,000	104,000	121,000	158,000	199,000
World, production	do.	1,310,000	1,390,000	1,410,000	1,660,000	1,670,000

do. Ditto.
[1]Data are rounded to no more than three significant digits.
[2]Domestic production plus imports minus exports.