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GARNET, INDUSTRIAL [ADVANCE RELEASE]

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Garnet, Industrial

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In 2019, U.S. production of crude garnet for industrial use was 104,000 metric tons (t) valued at $22.2 million, a 3% increase in tonnage from 101,000 t valued at $22.1 million in 2018. U.S. production of refined garnet in 2019 was 147,000 t valued at $64.7 million, an 11% decrease in tonnage and a 6% decrease in value from 166,000 t valued at $68.9 million in 2018. U.S. exports of industrial garnet in 2019 were 12,600 t, an 11% decrease from 14,200 t in 2018. Imports of garnet in 2019 were 208,000 t, an 18% decrease from 254,000 t in 2018. Imports accounted for 69% of U.S. apparent consumption of 300,000 t. World production was estimated to be 1.12 million metric tons (Mt) in 2019, a 10% decrease from 1.25 Mt in 2018 (table 1).

Garnet is the general name given to a group of complex silicate minerals, all 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 and andradite is the most common iron-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, 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 dominated the production of industrial garnet in the United States. Progressively higher production costs and narrowing profit margins during the past 20 years in the garnet industry resulted in the loss of noncompetitive producers. Because of the need to keep costs at a minimum, the most competitive companies were those that produced garnet in combination with one or two other minerals, had reserves that could be mined at a low cost, and could react rapidly to changes in market demand. The cost of industrial garnet was 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. Most industrial-grade garnet mined in the United States consisted of almandine (iron-aluminum silicate) and pyrope (magnesium-aluminum silicate), although some andradite (calcium-iron silicate) also was mined domestically. Industrial garnet was 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 industrial garnet in three States during 2019. 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. The fourth 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 obtained the production data in this report through a voluntary survey of the four U.S. industrial garnet producers; responses were received from two companies. The USGS estimated the production quantities and values of nonreporting companies based on industry sources, industry production trends, and past reports from producers adjusted using employment data from the Mine Safety and Health Administration.

In 2019, U.S. production of crude garnet concentrate for industrial use increased to 104,000 t from 101,000 t in 2018, and the value was slightly higher at $22.2 million from $22.1 million (table 1). The United States accounted for 9% of global industrial garnet production. In 2019, refined garnet production was 147,000 t valued at $64.7 million compared with 166,000 t valued at $68.9 million in 2018. The decrease in refined production was attributed to reduced imports. Refined garnet was processed from domestic mine production and imported crude garnet. 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. Garnet USA (a subsidiary of GMA Garnet Pty. Ltd.) mined almandine garnet at its quarry in southwestern Montana and processed garnet at its southeastern Pennsylvania facility. In New York, Barton mined an almandine-pyrope mixture from a quarry at Ruby Mountain. NYCO Minerals produced andradite garnet as a byproduct from its wollastonite mining operation at Oak Hill; some of the material was sold to a cement producer and some was processed by International Garnet (an Opta Minerals company) in Keeseville, NY.

In June 2019, Garnet USA opened a new garnet-processing plant in Coos Bay, OR (Cheong, 2019). This facility was expected to have a maximum refined garnet production capacity of more than 100,000 metric tons per year (Gobby, 2018).

Consumption

U.S. apparent consumption, defined as crude production plus imports minus exports, decreased by 12% to 300,000 t in 2019 from 341,000 t in 2018 owing to a decrease in imports (table 1). The major end uses for garnet in the United States in 2019 remained the same as those in 2018 and were estimated to be abrasive blasting (50%), water-jet cutting (35%), and water filtration media (10%); the remainder was used as abrasive powders, as an additive in nonslip coatings, in sandpaper, or other uses. Domestic industries that consumed garnet included aircraft and motor vehicle manufacturers, ceramics and glass producers, electronic component manufacturers, glass polishing, natural gas and petroleum producers, shipbuilding and maintenance, structural steel fabrication and maintenance, textile stonewashing, water filtration plants, and wood-furniture-finishing operations.

Most industrial garnet was 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 had 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 were competitors in these applications. In recent years, industrial garnet powders had 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 (Lismore, 2013). Garnet had replaced some silica sand in the abrasive blasting media market, but silica sand and mineral slag continued to be the most widely used media in blasting in 2019.

The U.S. oil-and-gas-drilling industry was one of the leading garnet-consuming industries, using garnet for cleaning drill pipes and well casings. Oil and gas producers also used garnet as reservoir-fracturing proppant, alone or mixed with other proppants. During 2019, the number of drill rigs operating in the United States was 1,075 at the beginning of the year, decreasing steadily through the year to 805 at the end of December. The average weekly drill rig count for 2019 was 943 operating rigs, compared with an average of 1,032 in 2018 (Baker Hughes Inc., 2020), indicating it was likely that less garnet was consumed in well drilling.

The aircraft manufacturing and shipbuilding industries used garnet for blast cleaning and for finishing metal surfaces. Similar uses included 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 was used to cut many different materials. Garnet powders were 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 abrasive grit 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 use of abrasives for water-jet cutting began to develop slowly in the late 1980s and early 1990s and then grew at a faster rate for the next 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 had been produced in larger standard sizes, up to 4 by 14 meters, and the ability to cut three-dimensional shapes using accessories and special software had 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 limited supply in 2019.

Low-quality industrial garnet, which has lower hardness and is more highly fractured than high-quality industrial garnet, 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 coal, garnet, and silica sand, had displaced older filtration methods because it provides better water quality. Garnet competed 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 2019, domestic unit values for crude garnet concentrates ranged from $200 to $240 per metric ton, with an average for the year of $213 per metric ton; this was a slight decrease from the 2018 average of $218 per metric ton. Domestic unit values for refined garnet sold during the year ranged from $400 to $550 per metric ton, with an average for the year of $440 per metric ton; this was a 6% increase from the 2018 average of $416 per metric ton.

The estimated average unit values of garnet from other leading producing countries (based on the customs value of import shipments) were as follows: India, $320 per metric ton; China, $240 per metric ton; Australia, $220 per metric ton; and South Africa, $140 per metric ton. During 2019, the average unit value of industrial garnet imported from all sources was $214 per metric ton of crude garnet, essentially unchanged from $215 per metric ton in 2018.

Foreign Trade

Exports of industrial garnet in 2019 were 12,600 t, and imports were estimated to be 208,000 t (Trade Mining, LLC, 2020). Exports decreased by 11% and imports decreased by 18% from those in 2018. The decrease in imports was the result of a decrease of imports from South Africa to supply the Fairless Hills, PA, processing plant. In 2019, South Africa (41%), China (19%), India (12%), and Australia (9%) supplied the majority of United States garnet imports for consumption, and 13 other countries supplied the remaining 11%. Garnet exports from the United States were shipped to Canada (31%), Mexico (25%), Trinidad and Tobago (5%), China (5%), Brazil (5%), and Peru (4%), and the remainder went to many other countries.

World Review

Total world industrial garnet production was 1.12 Mt in 2019, a 10% decrease from that in 2018. The leading global producers were Australia, 352,000 t; China, 310,000 t; South Africa, 179,000 t; India, 120,000 t; and the United States, 104,000 t; other countries accounted for the remaining 60,000 t.

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

Outlook

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 is expected to continue to displace mineral slag abrasives for blasting because it is safer for the environment and workers' health, garnet can be recycled, and it is less costly to dispose of after it has been used (Lismore, 2013).

Worldwide demand for industrial garnet is expected to increase, especially within the markets for abrasive grains for water-jet cutting and abrasive blasting media. Garnet demand 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, also is expected to increase after the resolution of the coronavirus disease 2019 (COVID-19) pandemic.

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TABLE 1
SALIENT INDUSTRIAL GARNET STATISTICS[1]

		2015	2016	2017	2018	2019
United States:						
Crude production:						
Quantity	metric tons	77,200	81,300	92,900	101,000	104,000
Value	thousands	$15,700	$16,300	$18,900	$22,100	$22,200
Refined garnet production:						
Quantity	metric tons	47,200	46,600	84,100	166,000	147,000
Value	thousands	$24,500	$24,000	$38,900	$68,900	$64,700
Exports:[2]						
Quantity	metric tons	11,000	10,100	17,700	14,200	12,600
Value	thousands	$8,260	$8,120	$11,900	$9,220	$9,370
Imports for consumption:[e, 3]						
Quantity	metric tons	212,000	156,000	54,200	254,000	208,000
Value	thousands	$47,900	$31,500	$16,500	$54,600	$44,500
Apparent consumption:[e, 4]						
Quantity	metric tons	278,000	227,000	129,000	341,000	300,000
Value	thousands	$55,400	$39,600	$23,600	$67,500	$57,400
World, production[e]	metric tons	1,010,000	1,130,000	960,000	1,250,000	1,120,000

[e]Estimated.
[1]Table includes data available through April 17, 2020. Data are rounded to no more than three significant digits.
[2]Source: U.S. Census Bureau; data adjusted by the U.S. Geological Survey.
[3]Sources: U.S. Census Bureau and Trade Mining, LLC; data adjusted by the U.S. Geological Survey.
[4]Domestic production plus imports minus exports.