

GARNET, INDUSTRIAL

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Garnet, which has several industrial uses, is a category of complex silicate minerals with similar crystalline structures and a wide variety of chemical compositions. The general chemical formula for garnet is $A_3B_2(SiO_4)_3$, where A can be calcium, magnesium, ferrous iron, or manganese; and B usually is aluminum, chromium, or ferric iron.

The industrial garnet industry in the United States and abroad is dominated by a few major producers in markets principally influenced by several key factors: (1) size and grade of reserves; (2) type and quality of garnet mined; (3) proximity of deposits to infrastructure and consumers; and (4) milling costs. Pricing is very competitive and suppliers must provide a high level of customer service (Kendall, 1997).

Most industrial grade garnet mined in the United States is a solid solution of almandine (iron-aluminum silicate) and pyrope (magnesium-aluminum silicate), but andradite (calcium-iron silicate) also is a domestic source for industrial uses. Industry primarily uses garnet as an abrasive material (6.5 to 9.0 Mohs hardness range); garnet also is utilized as filtration media because it is inert and resists degradation.

Production

The United States produces at least one-quarter of the industrial garnet mined worldwide; Australia reportedly is the only country that exceeds U.S. output. According to a survey conducted by the U.S. Geological Survey (USGS), six U.S. garnet companies, accounting for all domestic output, increased production to 64,900 metric tons valued at about \$6.1 million in 1997. (See table 1.) The producers were Barton Mines Corp., Warren County, NY; NYCO Minerals, Inc., Essex County, NY; Patterson Materials Corp., Wingdale, NY; Emerald Creek Garnet Co., Benewah County, ID; Cominco American Inc., Madison County, MT; and Sweetwater Garnet Inc., Madison County, MT. The Cominco and Sweetwater mines are relatively new producers that commenced operations in 1996. In addition to the six producers, International Garnet Abrasive Inc., Clinton County, NY, processed and sold garnet mined by NYCO Minerals in 1997. Also during the year, Western Garnet International, Ltd., the owner of Emerald Creek Garnet, signed a marketing agreement with Patterson Materials to sell garnet produced by Patterson. All of the producers reported their output and sales to the USGS.

Consumption

The United States is the world's largest consumer of industrial garnet, accounting for 25% to 35% of global consumption (Kendall, 1997; Gorrill, 1996; Roskill Information Services Ltd., 1996). Estimated U.S. consumption of industrial garnet was about 65,000 tons in 1997. Major end uses in the United States and their

estimated market share are as follows: air/water blasting media, 45%; water filtration, 15%; abrasive powders, 15%; and waterjet cutting, 7%. (Kendall, 1997; Gorrill, 1996). The garnet powders generally are used for glass/ceramic polishes, antislip paints, and antiskid surfaces. Domestic consumption approximates world demand patterns, except that filtration uses abroad account for a greater market share. Industrial sectors that utilize garnet include the petroleum industry (the largest consumer of blasting-grade garnet), filtration plants, aircraft and motor vehicle manufacturers, shipbuilding, wood furniture finishing operations, electronic component manufacturing, and ceramics and glass production.

Industrial garnet is used primarily as a loose-grain abrasive, especially for blast cleaning; lower quality industrial garnet is used as filtration media in water purification systems. High-quality, high-value garnet grain principally has been used for applications such as optical lens grinding and plate-glass grinding for more than a century; industrial diamond and fused aluminum oxide are competitors. In recent years, industrial garnet powders have been used for high-quality, scratch-free lapping of semiconductor materials and other metals. Other industrial applications include the manufacture of coated abrasives; hydrocutting; and the finishing of wood, leather, hard rubber, felt, and plastics. In the blast cleaning market, garnet is replacing silica sand where health risks associated with the inhalation of crystalline silica have curtailed its use.

Shipbuilding and aluminum aircraft industries use garnet for blast cleaning and finishing of metal surfaces. Similar uses include the cleaning and conditioning of aluminum and other soft metals as well as metals cleaning by structural steel fabrication shops. Mixed-media water filtration, using a mixture of sand, anthracite, and garnet, has displaced older filtration methods because it is more reliable and provides better water quality; ilmenite, magnetite, and plastics compete as filtration media. Garnet entrained in high-pressure streams of water also is used to cut many different materials. The manufacturers of nonskid floor paint also use alluvial and other low-cost garnets in their products.

In the coated-abrasive field, garnet has an intermediate place between low-cost quartz sand or staurolite and more costly manufactured abrasives (silicon carbide and fused alumina, for example); garnet reportedly is more efficient than quartz sand in most coated abrasive applications. However, because of garnet's friable nature and lower hardness, especially the lower grades, it cannot compete with manufactured abrasives in metalworking applications that require substantial metal removal.

Prices

Industrial garnet's very wide range of prices are dependent on type, source, quantity purchased, quality, and application. In

1997, reported values for crude concentrates ranged from about \$10 to \$75 per ton. Average values reported for refined garnet sold during the year by most producers ranged from \$60 to \$275 per ton, depending on quality, grain size, and quantities purchased. However, prices as high as \$400 per ton have been reported (Russell, 1997). Small quantities of the most highly processed garnet powders have sold for prices that equate to more than \$1,000 per ton.

Foreign Trade

The U.S. Department of Commerce no longer provides data that specifically identifies garnet exports and imports. Based on industry sources and a few reports from producers, however, the USGS estimates that U.S. exports and imports of industrial garnet were each 11,000 tons in 1997. Most U.S. garnet exports go to Australian, Asian, and European markets. It is estimated that Australia accounts for more than 80% of U.S. industrial garnet imports yearly; China and India also are U.S. import sources.

World Review

Garnet occurs worldwide in many rock types, principally gneisses and schists. Other sources include contact metamorphic rocks, crystalline limestones, pegmatites, and serpentinites. Additionally, garnet is found near veins formed at high temperatures. Alluvial garnet is associated with heavy mineral sand and gravel deposits in many parts of the world. Despite the large and numerous occurrences of garnet, however, relatively few commercially viable garnet deposits have been discovered.

In addition to the United States, significant quantities of industrial grade garnet are mined in several countries abroad. The most significant foreign producers are Australia, India, and China; all have growing foreign and domestic markets. Other producers include the Czech Republic, Pakistan, Russia, Turkey, and the Ukraine; output in most of these countries is for domestic consumption. Estimates of total output by all producers worldwide range from 180,000 tons to 250,000 tons, but probably is not much greater than 200,000 tons (Kendall, 1997). Total global supply is roughly divided among markets as follows: blasting media, 45%; water filtration, 25%; abrasive powders, 10%; waterjet cutting, 10%; and other uses, 10% (Kendall, 1997; Gorrill, 1996).

Outlook

Although growing domestic and world demand encourages new companies to enter the garnet industry, the larger and more experienced producers will continue to be the dominant suppliers in the coming decade. Additional supplies to meet greater demand will be based on new mines as well as the expansion of existing operations. At least 120,000 tons of new production capacity is under construction or is planned worldwide; this growth could

double later in the next decade (Kendall, 1997). Capacity expansion would significantly restrain price increases as well as meet anticipated market needs. Most of the new capacity growth is expected in Australia, India, and the United States.

All forecasts indicate growth in world demand for industrial garnet; the most optimistic report projects an average annual increase of 7% during the next 10 years (Roskill Information Services Ltd., 1996). Some forecasters predict that global markets for industrial garnet may increase by more than 160,000 tons early in the next decade. Markets for garnet blasting media and waterjet cutting, in particular, could more than double in the next few years if the expansion of industry and manufacturing continues in leading national economies. Moreover, reduced use of silica sand to avoid health risks in the blast cleaning sector could create significant market opportunities for garnet producers.

If U.S. production capacity does not increase sufficiently in the next several years, growing domestic markets will be more import dependent. Nevertheless, greater U.S. reliance on imports is not expected to become a major problem because major domestic producers own key sources of garnet supply abroad. Furthermore, if industrial garnet is not available to meet growing demand, other natural and synthetic abrasives (*See Consumption section above*) could serve as substitutes to some extent for major end uses. In many cases, however, the substitutes would entail greater costs or sacrifices in quality.

References Cited

- Russell, Alison, 1997, Prices: Industrial Minerals, no. 357, p. 102.
Gorrill, L.E., 1996, World garnet review—Supply and markets: 12th Industrial Minerals International Congress, Chicago, IL, April 21-24 proceedings, p. 85-87.
Kendall, Tom, 1997, Garnet—Nice work if you can get it: Industrial Minerals, no. 254, p. 31.
Roskill Information Services Ltd., 1996, Soaring demand for garnet: London, Roskill news release, June 20, 3 p.

SOURCES OF INFORMATION

U.S. Geological Survey Publications

Garnet. Ch. in United States mineral resources, U.S. Geological Survey Professional Paper 820, 1973.

Industrial Garnet. Ch. in Mineral Commodity Summaries, annual.¹

Other

Industrial Minerals (monthly).

Industrial Minerals Prices and Data (annual).

North American Minerals News (monthly).

¹Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
SALIENT U.S. INDUSTRIAL GARNET STATISTICS 1/

Year	Crude production		Sold or used 2/	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1993	44,000	\$4,440	51,500 r/	\$12,500 r/
1994 r/	44,700	3,430	41,100	10,700
1995 r/	46,300	3,850	39,900	10,100
1996 r/	60,900	5,630	46,200	11,200
1997	64,900	6,050	53,600	12,500

r/ Revised.

1/ Data are rounded to three significant digits.

2/ Excludes unreported exports estimated to increase from 4,000 tons in 1993 to 6,000 tons in 1997.