

GARNET, INDUSTRIAL

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Although garnet has been used as a gemstone for centuries, its angular fractures and relatively high hardness and specific gravity combined with its ability to be recycled make it desirable for many industrial applications. These uses range from a filtration medium to a waterjet abrasive.

Garnet is the name for a group of complex silicate minerals, all with crystalline structures classified in the isometric crystal system and similar chemical compositions. 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 six 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, 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 discovered.

Production

The U.S. industrial garnet industry is dominated by a few major producers. The industrial garnet values are 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. Pricing within the U.S. garnet industry is very competitive, and suppliers must provide a high level of customer service. Most 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.

The U.S. Geological Survey (USGS) obtained the data in this report through a survey of U.S. industrial garnet producers. Four of the five domestic producers reported their output and sales to the USGS, and production amounts and values for the nonreporting company were estimated. Three U.S. companies accounted for all domestic production—one in Idaho and two in New York. Production decreased by 24% to 29,200 t, and the value of annual production decreased by about 30% to \$3.17 million in 2003 (table 1). Industrial garnet sold by U.S. producers decreased in quantity by about 12% during 2003. The producers were Barton Mines Co. LLC in Warren County, NY; Emerald Creek Garnet Co. in Benewah County, ID; and NYCO Minerals, Inc. in Essex County, NY. Patterson Materials Corp. in Dutchess County, NY, closed down its quarry and operation at the end of 2002 and only sold from stocks during 2003. Two firms in Montana did not operate during 2003.

Ruby Garnet owned by Montana-Oregon Investment Group LLC in Madison County, MT, has closed and is now for sale, and Sweetwater Garnet Inc. in Madison County was in foreclosure at the end of the year. In addition to the producers cited above, International Garnet Abrasive Inc. in Clinton County, NY, processed and sold all the garnet mined by NYCO Minerals in 2003.

Consumption

The United States is the world's largest consumer of industrial garnet (Harris, 2000). In 2003, the estimated U.S. apparent consumption of industrial garnet was 83,200 t. The United States accounted for more than 35% of global industrial garnet use.

The major end uses for garnet in the United States and their estimated market share in 2003 were abrasive blasting media, 35%; waterjet cutting, 30%; water filtration, 15%; abrasive powders, 10%; and other, 10%. The gap between the abrasive blasting and waterjet cutting sectors is narrowing as the growth rate of the waterjet cutting sector is slightly higher. The domestic industries that consume garnet include the aircraft and motor vehicle manufacturers, ceramics and glass producers, electronic component manufacturers, filtration plants, the petroleum industry, shipbuilders, and wood-furniture-finishing operations.

Estimated worldwide end uses and their estimated market shares are abrasive blasting media, 60%; waterjet cutting, 20%; water filtration, 10%; and other end uses, 10% (Gorrill, 2003).

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 blast cleaning 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 (Harris, 2000). The U.S. petroleum industry is one of the largest garnet-consuming industries, using garnet for cleaning drill pipes and well casings. The shipbuilding and aluminum aircraft 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/ceramic polishes.

Low-quality industrial garnet, which has lower hardness and is more highly fractured, is used as a filtration medium in water purification 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 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.

Prices

The wide price range of industrial garnet is based on the application, quality, quantity purchased, source, and type. During 2003, average values for crude concentrates ranged from about \$53 per metric ton to \$220 per ton, with an overall domestic average for the year of \$108 per ton. The average values for refined garnet sold during the year ranged from \$61 per ton to \$441 per ton, with an overall domestic average for the year of \$329 per ton.

Foreign Trade

The U.S. Department of Commerce 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. Based on reports from some producers and other industry sources, imports and exports of industrial garnet were estimated to be 30,800 t and 11,000 t, respectively, in 2003. This level of imports was an increase of about 34% compared with that of 2002, and exports increased by about 6% from those of 2002. Australia provided almost 47%, India about 35%, and China approximately 17% of U.S. industrial garnet imports for consumption. Australia, China, and India continued to gain importance as garnet exporters. Most U.S. exports of garnet are shipped to Asian, Australian, and European markets.

World Review

Total world industrial garnet production was estimated to be 440,000 t (Gorrill, 2003). Australia, China, India, and the United States were the leading producers in 2003. The United States produced about 7% of the industrial garnet mined worldwide. Production in both Australia and India exceeded United States production. Russia and Turkey have been mining garnet in recent years, primarily for domestic markets. Small mining operations also are located in Canada, Chile, the Czech Republic, Pakistan, South Africa, Spain, Thailand, and the Ukraine. Production in most of these countries is for domestic use.

Australian industrial garnet production and exports have increased and are expected to continue increasing. China and India also have increased garnet output and have become significant garnet sources for other countries.

Outlook

For the short term, excess production capacity combined with stocks that vary in grain size, mineral type, and quality will keep prices down. Garnet producers could benefit from the enforcement of existing regulations and tighter environmental and health controls on abrasive blasting. The implementation of U.S. clean water regulations and the improvement of potable water supplies in developing countries also will benefit garnet suppliers.

The garnet industry has encountered higher production costs and tighter profit margins during recent years. This has 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 demands.

Worldwide industrial garnet demand is expected to grow at a rate of 3% to 5% per year during the next 5 years. Markets for waterjet cutting and blasting media are expected to exhibit the highest growth (Roskill Information Services Ltd., 2000, p. 62, 66).

Demand for garnet polishing powders, which are used in polishing television and monitor screens, is declining with the emergence of flat screen systems that do not require garnet polishing during their manufacture. In coming years, as the affordability and popularity of flat screen technology increases, a further decrease in demand for garnet polishing powders is probable (Gorrill, 2003).

Recent worldwide increases in petroleum prices have stimulated an increase in exploration for petroleum resources. This exploration increase should provide opportunities for increased use of garnet blasting media for cleaning drill pipe. Increased defense spending in the United States could lead to increased garnet demand, since the aircraft manufacturing and shipbuilding industries use significant amounts of garnet for blast cleaning and finishing of metal surfaces and for use in waterjet cutting.

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GENERAL SOURCES OF INFORMATION

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TABLE 1
SALIENT U.S. INDUSTRIAL GARNET STATISTICS¹

Year	Crude production		Sold or used ²	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1999	60,700	\$6,170	43,900	\$11,600
2000	60,200	7,060	51,300	14,000
2001	52,700	6,430	46,200	13,500
2002	38,500	4,500	37,500	11,100
2003	29,200	3,170	33,100	10,900

¹Data are rounded to no more than three significant digits.

²May exclude some unreported exports.