

# GARNET, INDUSTRIAL

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**Domestic survey data and table were prepared by Christine Pisut, statistical assistant.**

Garnet has been used as a gemstone for centuries. However, the angular fractures and relatively high hardness and specific gravity of garnet combined with its ability to be recycled make it desirable for many industrial applications. The utility of garnet in a variety of uses ranging from a filtration medium to a waterjet abrasive is a result of its complex mineralogy.

Garnet is the general name for a group of complex silicate minerals with isometric crystal structures and similar chemical compositions. The general chemical formula for the garnet minerals is  $A_3B_2(SiO_4)_3$ , where A can be calcium, magnesium, ferrous iron, 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 garnets, iron garnets, and chromium garnets. 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 large and 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. Industrial garnet market 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 for industrial uses.

U.S. companies produced approximately 9% of the estimated 440,000 metric tons (t) of industrial garnet mined worldwide in 2002 (Gorrill, 2003). According to a survey conducted by the U.S. Geological Survey (USGS), five U.S. companies accounted for all domestic output—one in Idaho, one in Montana, and three in New York. Production decreased by 27% to 38,500 t, and the value of annual production decreased by about 30% to \$4.50 million in 2002 (table 1). Industrial garnet sold by U.S. producers decreased in quantity by about 19% during 2002. The producers were Barton Mines Co. LLC in Warren County, NY; Emerald Creek Garnet Co. in Benewah County, ID; Montana-Oregon Investment Group LLC in Madison

County, MT; NYCO Minerals, Inc. in Essex County, NY; and Patterson Materials Corp. in Dutchess County, NY. All but one of the domestic producers reported their output and sales to the USGS, and production amounts and values for the nonreporting company were estimated. 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 2002.

Sweetwater Garnet Inc. in Madison County, MT, did not operate its mine during 2002. Patterson Materials Corp. in Dutchess County, NY, closed down its quarry and operation at the end of 2002 and will only be selling from stocks during 2003.

## Consumption

The United States is the world's largest consumer of industrial garnet (Harris, 2000). In 2002, the U.S. estimated apparent consumption of industrial garnet was 54,200 t, which was a 9% decrease from the 2001 apparent consumption. The United States accounts for more than 25% of global industrial garnet use.

The major end uses for garnet in the United States and their estimated market share in 2002 were abrasive blasting media, 35%; waterjet cutting, 30%; water filtration, 15%; abrasive powders, 10%; and other end uses, 10%. The gap between the abrasive blasting and waterjet cutting sectors is narrowing because the growth rate of the waterjet cutting sector is slightly higher. The domestic industrial sectors 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 a loose-grain abrasive because of its hardness, which ranges from 6 to 7.5 on the Mohs scale. Lower quality industrial garnet is used as a filtration medium in water purification systems because of its relative inertness and resistance to chemical degradation. 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 this application. In recent years, industrial garnet powders have been used for high-quality, scratch-free lapping of semiconductor materials and other metals. Other applications include the manufacture of coated abrasives, hydrocutting, and the finishing of wood, leather, hard rubber, felt, and plastics. Garnet has been slowly replacing silica sand in the blast cleaning market because garnet

does not have the health risks associated with the inhalation of airborne crystalline silica dust. However, at present, 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. Crude oil price increases during 2002 allowed for additional equipment maintenance activities and increased the petroleum industry's use of industrial garnet.

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 is well suited for water filtration and treatment because it is relatively heavy and chemically stable. 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. Garnet competes with silica sand, ilmenite, magnetite, and plastics as a filtration medium. Garnet entrained in high-pressure streams of water also is used to cut many different materials. Garnet powders generally are used for glass/ceramic polishes, antislip paints, and antiskid surfaces.

In the coated-abrasive market, garnet falls between low-cost quartz sand or staurolite and more costly manufactured abrasives, such as silicon carbide and fused alumina. 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 2002, average values for crude concentrates ranged from about \$53 per metric ton to \$220 per ton, with an overall domestic average of \$117 per ton for the year. The average values for refined garnet sold during the year ranged from \$61 per ton to \$331 per ton, with an overall domestic average of \$165 per ton for the year. These overall domestic average values are about 5% lower than those of 2001.

## Foreign Trade

The U.S. Government 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 23,000 t and 10,400 t, respectively, in 2002. This level of imports was about the same as that of 2001, and exports increased by about 4% from those of 2001. Australia provided almost 37%, China about 35%, and India approximately 28% of industrial garnet imported into the United States for consumption. Australia, China, and India continue to gain importance as garnet exporters. Most

garnet exported from the United States was 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 most significant producers in 2002. The United States produced approximately 9% of the industrial garnet mined worldwide. Production in both Australia and India exceeded that of the United States. Russia and Turkey have been mining garnet in recent years, primarily for domestic markets. Additional garnet resources with small mining operations are located in Canada, Chile, the Czech Republic, Pakistan, South Africa, Spain, Thailand, and Ukraine, and output in most of these countries is for their 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 more significant garnet sources for other countries.

## Outlook

During the first quarter of 2002, North American industrial garnet markets rebounded from the sudden sharp drop of the fourth quarter of 2001.

For the short term, excess production capacity combined with supplies that vary in quality, grain size, and mineral type 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.

During recent years, the garnet industry has encountered higher production costs and tighter profit margins, which 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). With recent worldwide increases in petroleum prices, there has been an increase in petroleum exploration. 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 for blast cleaning and finishing of metal surfaces.

## References Cited

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TABLE 1  
 SALIENT U.S. INDUSTRIAL GARNET STATISTICS<sup>1</sup>

Year	Crude production		Sold or used <sup>2</sup>	
	Quantity (metric tons)	Value (thousands)	Quantity (metric tons)	Value (thousands)
1998	74,000	\$7,070	51,900	\$12,600
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

<sup>1</sup>Data are rounded to no more than three significant digits.

<sup>2</sup>May exclude some unreported exports.