

GARNET, INDUSTRIAL

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Garnet is the general name given to a group of complex silicate minerals with similar crystalline structures and diverse 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—aluminum garnets, iron garnets, and chromium garnets. The minerals in the aluminum garnet group are almandine or almandite, pyrope, grossularite, and spessartite. Iron garnet is andradite, and chromium garnet is uvarovite. 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.

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

Production

The U.S. industrial garnet industry is dominated by a few major producers. The industrial garnet market 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. 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), although some andradite (calcium-iron silicate) also is mined domestically for industrial uses.

The United States produced approximately 16% of the industrial garnet mined worldwide in 2001. According to a survey conducted by the U.S. Geological Survey (USGS), six U.S. companies in Idaho, Montana, and New York accounted for all domestic output. Production decreased by 12% to 52,700 metric tons (t), and the value of the annual production decreased by about 9% to \$6.43 million in 2001 (table 1). 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; Patterson Materials Corp. in Dutchess County, NY; and Sweetwater Garnet Inc. in

Madison County, MT. All but one of the producers reported their output and sales to the USGS, and production 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 2001.

The Sweetwater Garnet Mine, which had been shut down since 1999, began its mining operations again in June 2001, using new mining equipment. Sweetwater Garnet also installed new concentrating equipment and continued making improvements to their milling equipment during 2001.

Consumption

The United States was the world's largest consumer of industrial garnet (Harris, 2000). In 2001, the U.S. apparent consumption of industrial garnet was estimated to be 61,300 t, which was a 141% increase from the 2000 apparent consumption. The United States accounts for 25% to 35% of global industrial garnet use. The large increase in apparent consumption was due to a 45% decrease of U.S. producer stocks. The producer stocks decrease was primarily because of Sweetwater Garnet processing from inventory stocks for 9 months before they resumed mining operations.

Major end uses for garnet were waterjet cutting, 35%; abrasive blasting media, 30%; water filtration, 15%; abrasive powders, 10%; and other end uses, 10%. Domestic use patterns are approximately the same as world use patterns, except that filtration uses abroad accounted for a greater market share. U.S. industries that consumed industrial garnet included aircraft manufacturers, ceramics and glass producers, electronic component manufacturers, motor vehicle manufacturers, the petroleum industry, shipbuilders, water filtration plants, and wood-furniture-finishing operations.

The majority of 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 chemical degradation resistance. 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. This market displacement is happening because of the health risks associated with the inhalation of airborne crystalline silica dust having

curtailed its use, but silica sand and slag are still 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 2001 allowed for 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. 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 is also used to cut many different materials. The garnet powders generally are used for glass/ceramic polishes, antislip paints, and antiskid surfaces.

In the coated-abrasive market, garnet has an intermediate place 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 was based on the type, source, quantity purchased, quality, and application. In 2001, average values for crude concentrates ranged from \$53 to \$267 per metric ton, and average values for refined garnet sold during the year ranged from \$61 to \$441 per ton. Quantities sold by U.S. producers decreased by approximately 10%, and the value of sales decreased by about 4% during 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, however, exports and imports of industrial garnet were estimated to be about 10,000 t and 23,000 t, respectively, in 2001. Most U.S. garnet exports went to Asian and European markets.

About 40% to 45% of the U.S. garnet imports were from Australia, 35% to 40% from India, and 15% from China (Frank Alsobrook, President, Alsobrook and Co., Inc., oral commun., June 18, 2001). Australia historically has accounted for most of the industrial garnet imported by the United States. Imports of garnet from India are increasing, and China and India have the potential to gain a significant share of the U.S. market (Frank Alsobrook, President, Alsobrook and Co., Inc., oral commun., June 18, 2001).

World Review

Total world industrial garnet production was estimated to be 335,000 t (Roskill Information Services Ltd., 2000, p. 16). Australia, China, India, and the United States were the most significant producers in 2001. The United States produced approximately 16% of the industrial garnet mined worldwide. Australia and India exceeded U.S. production. 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. Output in most of these countries is for domestic use (Frank Alsobrook, President, Alsobrook and Co., Inc., oral commun., June 18, 2001).

Australian exports of garnet are expected to continue to increase. China and India also have increased garnet output and are likely to become more significant garnet sources for other countries.

Outlook

Industrial garnet sold by U.S. producers decreased by about 10% during 2001. This was probably because of the sudden and sharp drop in North American markets during the fourth quarter of 2001 (Western Garnet International Ltd., 2002, p. 1). However, during the first quarter of 2002, North American markets rebounded. Some forecasts indicate that domestic markets for industrial garnet may continue to grow in the next several years. Worldwide industrial garnet demand is expected to grow over the next 5 years at a rate of 3% to 5% per year. 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 and in the use of garnet blasting media by the oil and gas industry 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. Substitution for silica sand by garnet in abrasive blasting markets also will continue but at a pace slower than expected by the most optimistic forecasts because silica sand has a price advantage and is more accessible to consumers. Growing world demand encourages new companies to enter the garnet industry, but the current major producers will probably continue to be the dominant suppliers in the first decade of the 21st century.

Significant stocks of industrial garnet are held in Australia and India. These excess production stocks coupled with possible future expansions not only will meet anticipated market needs but may also result in widespread garnet price decreases until supply and demand come into balance.

References Cited

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GENERAL SOURCES OF INFORMATION

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Other

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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)
1997	64,900	\$6,050	53,600	\$12,500
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

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

2/ May exclude some unreported exports.