

# Kyanite

*U.S. Geological Survey mineral commodity specialist Michael J. Potter has compiled the following information about kyanite, a critical component in refractory and ceramic products.*

Kyanite and related minerals are used in making refractories, which are materials that can withstand high-temperature environments, generally in excess of 1,100 degrees Celsius. Refractories form an inner lining to furnaces, kilns and other containers with which molten metals and glass come into contact. Fifty to 70 percent of global refractory consumption is related to the steel industry.

Kyanite, andalusite and sillimanite are minerals with the same chemical formula, but with different crystal structures and chemical properties. The theoretical composition is about 63 percent alumina and 37 percent silica. The three minerals are sometimes referred to as the "sillimanite group." All of these minerals convert to mullite (about 88 percent) and silica (about 12 percent) upon "calcining," or heating from about 1,250 degrees Celsius to 1,500 degrees Celsius.

Examples of refractories that contain andalusite, kyanite and/or mullite include firebrick, insulating brick, kiln furniture, refractory shapes and monolithic refractories (made of a single piece or as a continuous structure), such as castables (refractory concrete), gunning mixes, mortars and plastics. Monolithic refractories are used in many of the same consuming industries as refractory brick, including iron and steelmaking and nonferrous metal smelting. Iron and steel production is the leading use of refractories worldwide.

The interlocking grain structure of andalusite, kyanite and mullite gives added mechanical strength to refractories and other nonrefractory ceramic materials. Other end uses of kyanite and related materials include brake shoes and pads, electrical porcelain, foundry use, precision casting molds and sanitaryware.

Kyanite is mined only in a few countries. The United States is the largest producer, with all of the kyanite coming from central Virginia. Kyanite Mining Corporation's ore deposits are kyanite quartzites containing 15 to 40 percent kyanite and usually about 5 percent of other minerals such as mica, pyrite and rutile. The remainder is quartz. Company data are proprietary, but a nongovernmental estimate puts U.S. output at 90,000 metric tons per year. This includes both raw, marketable kyanite product and calcined kyanite (mullite). An estimated one-third of the production is exported to countries worldwide.

South Africa is the leading producing country of andalusite, with an estimated 235,000 metric tons of marketable output of the mineral in 2005. France produces an estimated 65,000 tons per year of andalusite. China reportedly has some production of andalusite, but official data have not been received by the U.S. Geological Survey (USGS). A company in North Carolina mines a deposit containing andalusite, pyrophyllite and sericite (mica), and sells blends of the minerals to producers of ceramics and refractories.

Outside of China and India, sillimanite has had limited production. The mineral can occur in metamorphic rocks but is not often in a form that can be easily extracted. According to a nongovernmental source, China may produce an estimated 20,000 tons per year of sillimanite, but USGS has not obtained official data. India's long coastline has large deposits of beach sands that contain heavy minerals, including sillimanite and zircon. The country's output of sillimanite is an estimated 15,000 tons per year. Extensive research is being carried out to utilize the beach-sand-derived sillimanite and zircon. For example, mullite aggregate was developed by reaction sintering of sillimanite sand and calcined alumina. Also, high-alumina bricks and high-temperature insulating bricks have been developed using sillimanite sand obtained from beach sands.

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Sample of kyanite. Image from *Minerals in Your World*.