COLOR AND IRON IN SILLIMANITE

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Most naturally occurring sillimanite is colorless, white, or gray, for sillimanite is generally too fine-grained or its intrinsic color too faint to be noticed. Coarse-grained sillimanite is relatively rare but, where found, is not uncommonly colored. Yellow-green, brown and blue varities have been described.

Yellow-green sillimanite has been found in pegmatites in granulite-facies rocks. The color is due to ferric iron that is evenly distributed throughout the crystals. Polarized optical absorption spectra were taken at 296K and at 78K on a crystal from Reinbolt Hills, Antarctica. This sillimanite contains 1.2-1.3 percent Fe_2O_3 and no more than 0.1 percent TiO_2; other minor elements are present in trace amounts only. Prominent absorption bands were observed in α at 462, 440, and 412 nm, and in γ at 615 and 362 nm. The pattern of absorption bands is distinctly different from that of ferric iron in the octahedral site of kyanite. The intensity of these bands (ϵ = 1-3) suggests that much of the iron present is in a tetrahedral site in the sillimanite structure.

Brown sillimanite is found sporadically in upper amphibolite-facies schists and gneisses. The color is considerably more intense and the pleochroism more marked than in the yellow-green variety. The color appears not to be due to ferric iron alone.

Blue sillimanite has been reported from five localities. Two of these are the gem gravels of Ceylon and Burma, where the paragenesis is not known. At two localities, Kilbourne Hole, New Mexico, USA (Padovani and Carter, 1973, 1974) and Bournac, Haute Loire, France (Caillère and Pobequin, 1972), the blue sillimanite is found in xenoliths of gneiss in volcanic rocks. At the fifth locality in New Zealand (Hattori, 1967, N.Z. J. Geol. Geoph. *10*, 269) it occurs in garnet gneiss near a major tectonic feature, the Alpine Fault. The mineralogy and chemistry of these sillimanite-garnet gneisses suggests they crystallized above the stability limit of muscovite, probably under granulite facies conditions. The blue color of the sillimanite from the xenoliths appears to be related to heating, by the basaltic magma, of sillimanite formed under high-grade regional metamorphic conditions. The color in the New Zealand sillimanite, which also originally crystallized under high-grade conditions, may be due to rapid changes in physical conditions associated with tectonic movements of the Alpine Fault.

The iron content of most natural sillimanites ranges from near zero to 1.3 percnet Fe_2O_3; 2.6 percent has been reported from a volcanic xenolith (Cameron and Ashworth, 1972, Nature Phys. Sci. 235, 134). The iron content of sillimanite appears to be independent of the iron content of the host rock. The iron content is greater in sillimanite coexisting with magnetite or hematite than in that coexisting with graphite, leading many workers to conclude that the iron content increases with increasing partial pressure of oxygen in the fluid phase during metamorphism. A more useful indicator of the partial pressure of oxygen for a given grade of metamorphism, particularly in rocks lacking magnetite, hematite, or graphite, is the extent of hematite solid solution in ilmenite. In granulite-facies rocks, the iron content of sillimanite increases with increasing hematite content in associated ilmenite. The positive correlation between iron content in sillimanite and the inferred partial pressure of oxygen in the fluid phase believed to be in equilibrium with the mineral phases during metamorphism is consistent with the optical absorption data, which indicate that the iron in sillimanite is ferric.

The relation of iron content in sillimanite to temperature and pressure is less clear. The most iron-rich sillimanites are found in granulite-facies rocks and in contact-metamorphic rocks. On the other hand, the iron content of sillimanites crystallized at high temperature (granulite-facies and contact-metamorphic rocks) and at relatively low temperatures (amphibolite facies) has about the same range: 0.1 to 1 percent.

The analyses would thus suggest that although high temperature might promote the incorporation of iron in sillimanite, its effect is far less important than that of oxygen partial pressure. The effect of pressure on the iron content of sillimanite appears to be minimal.