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Hydrothermal formation and alteration of laumontite in hornblende schist near Huntly, Aberdeenshire

LAUMONTITE occurs in hydrothermally altered igneous rocks (Deer, Howie, and Zussman, 1963) and in sedimentary rocks, particularly sandstone, as a result of diagenesis (e.g. Vine, 1969; Madsen and Murata, 1970). It is also characteristic of rocks that have undergone incipient metamorphism and is widespread in the zeolite facies (Coombs *et al.*, 1959). In many instances the mineral is a degradation product of calcic plagioclase feldspar although in metamorphic sequences it may develop through the breakdown of zeolites such as analcime and mordenite. Theoretical and experimental evidence (Liou, 1971) indicates that the stability field of laumontite is defined by a number of reactions that depend largely on *P–T* conditions. One such reaction, first proposed by Seki (1966), is:

$$\underset{\text{laumontite}}{2CaAl_2Si_4O_{12}.4H_2O} \rightarrow \underset{\text{prehnite}}{Ca_2Al_2Si_3O_{10}(OH)_2} + \underset{\text{kaolinite}}{Al_2Si_2O_5(OH)_4} + \underset{\text{quartz}}{3SiO_2} + 5H_2O$$

The object of this note is to describe an outcrop of hydrothermally altered rock where there is good evidence that this reaction had taken place.

The outcrop is located by a stream, near Bowman Hillock, about 4 km due west of Huntly, Aberdeenshire (NJ481395), near a small serpentinite mass. The rock is a hornblende schist, a type widespread in the Scottish Dalradian sequence, and gives the impression of being completely decomposed, resembling the deeply weathered rock that is so common in this part of Scotland (Fitzpatrick, 1963). Closer inspection reveals that although much of the rock is quite incoherent and friable, other parts are relatively unaltered. Samples showing three different stages of decomposition were collected and examined by X-ray diffraction and optical microscopy.

Coherent rock with well-defined schistosity. Thin sections revealed an abundance of long, slender prisms of amphibole, often well oriented, set in a groundmass of granular, generally untwinned feldspar. There are occasional flakes and shreds of colourless chlorite, which is probably a magnesium-rich variety. X-ray powder patterns indicate that the feldspar is sodic with an albite-oligoclase composition.

Incoherent rock with poorly defined schistosity. Optical microscopy shows that the amphiboles are now more randomly arranged, with signs of fragmentation and splitting. The feldspar has been replaced completely by laumontite (the name is used in the general sense), which occurs as slightly elongate crystals with a granular texture. The mineral extinguishes at angles between 30° and 40°, although extinction is rarely complete. It shows low first-order interference colours, a poorly defined, negative biaxial interference figure of moderate 2V and, in some grains, intersecting sets of cleavages at right angles. X-ray powder diffraction confirmed the identity of laumontite, crystals picked out from resin-impregnated blocks yielding a pattern virtually identical with that recorded for leonhardite (a slightly dehydrated variety of laumontite) by Lapham (1963).

Completely decomposed rock with no sign of schistosity. Optical observations show that at this stage the amphiboles are randomly arranged and extensively fragmented. The laumontite seems to have been completely converted to an isotropic mass of clay, which shows distinctive shatter cracks. Associated with the clay are radiating clusters of a highly birefringent mineral with the optical properties of prehnite. Identification was confirmed by X-ray diffraction of hand-picked material, which yielded a pattern identical with that on ASTM card 7–333. The clay was separated by sedimentation and then examined by X-ray diffraction and electron microscopy. The powder pattern was identical with that of metahalloysite (Brindley, 1961) with a strong peak at 7·45 Å, although it may well be that in outcrop this mineral occurs in the fully hydrated form. Electron microscopy of the clay showed an abundance of particles with the tubular morphology typical of halloysite (Bates, 1971).

It appears, therefore, that the Bowman Hillock outcrop affords a good example of laumontitization of sodic plagioclase feldspar, probably by means of calcium-rich hydrothermal solutions, and subsequent decomposition into prehnite plus a kaolin mineral as suggested by Seki (1966).

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