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PYROMORPHITE: A SECONDARY LEAD MINERAL

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Abstract: Pyromorphite [$Pb5(PO_4)_3Cl$] is an oxidised weathering product of galena found at localities in the Derbyshire Peak District. It is an important soil lead mineral, possibly controlling the levels of lead in natural waters. Its formation may be limited by the availability of phosphorus.

Pyromorphite has the chemical formula $Pb_5(PO_4)_3Cl$. It is a secondary lead mineral formed by weathering of the common lead ore, galena (PbS) under oxidising conditions.

The following micrographs are of a pyromorphite specimen collected from Tideslow Rake [GR SK145782] in the Derbyshire Peak District by Dr. N. Butcher approximately 5m below ground surface. Similar specimens have been found in the Winster area approximately 20kms south-east of Tideslow Rake. Both specimens were associated with basaltic horizons. The pictures were obtained using a scanning electron microscope at a magnification of 500-10,000x at Imperial College.

Plates 1 and 2 show well formed fans of hexagonal prisms, reflecting the crystal structure of pyromorphite (Plate 3). The splayed nature of the fans is typical of in-situ weathering of ore deposits. Plate 4 is an example of interlocking crystals. X-ray spectra show that the sample contains lead, phosphorus and chlorine.

Pyromorphite has an apatite structure similar to that of bone material, hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$ (Neuman and Neuman 1953). A limited amount of lead can substitute for calcium in bone material. Similarly, a small amount of calcium can substitute for lead in pyromorphite.

Pyromorphite has been found in the oxidised zone of lead ore deposits at many localities (Palanche 1951; Read 1971). Grains of pyromorphite have been found in lead-mine waste soils from Winster by the author (unpublished results) but it is unclear whether these formed in the soil from galena or were incorporated into the soil in their present form.

A thermodynamic study (using experimental and predicted data) of pyromorphites and other lead minerals by Nriagu (1973; 1974) concluded that chloropyromorphite (previous reports refer to chloropyromorphite as simply pyromorphite) is the most stable lead mineral under the geochemical conditions occurring in the surface environment i.e. Eh = +0.2 to +0.8, pH = 4 to 11. It has an extremely low solubility [$K_{sp} = 10^{-84.4 +/- 0.1}$ (Nriagu 1973)] and may be important in maintaining a low concentration of lead in natural waters (Wedepohl et al 1969; Nriagu 1974).

The formation of pyromorphite can be limited by the availability of either chlorine or phosphorus. Chlorine is widely distributed in the surface environment and only small amounts of chlorine are required to form pyromorphite. Phosphorus however, is a major constituent of pyromorphite but occurs only as a trace element in most soils. Therefore, the availability of phosphorus is likely to be a limiting factor in the formation of pyromorphite, especially in the case of an oxidised lead deposit where lead is abundant. If phosphorus is not available, galena will weather to anglesite ($PbSO_4$) or cerussite ($PbCO_3$) depending on the pH (Garrels and Christ 1965).

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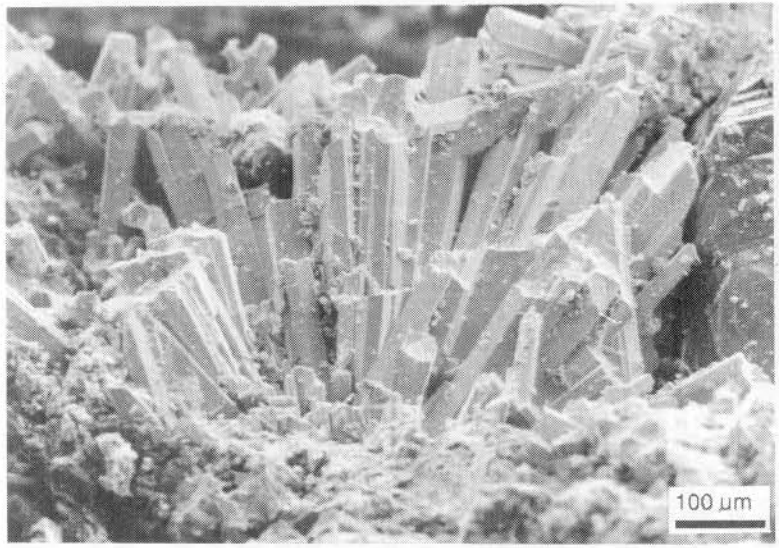

Plate 1.

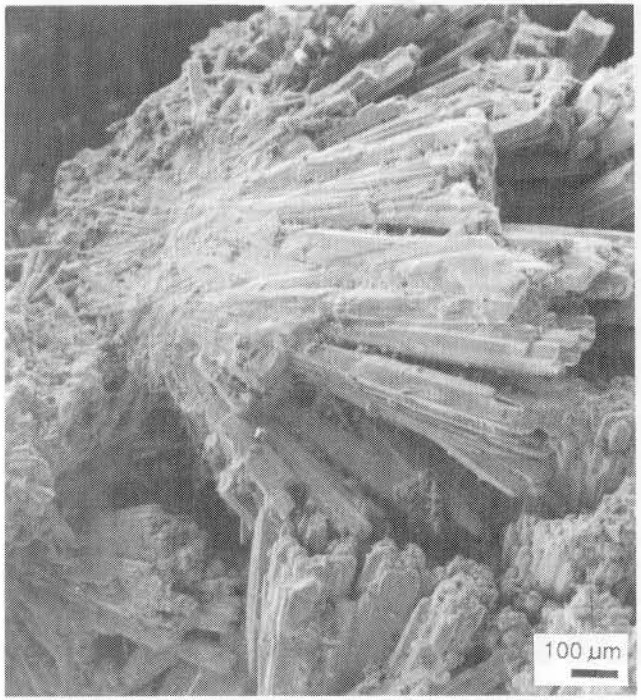

Plate 3.

Plate 2.

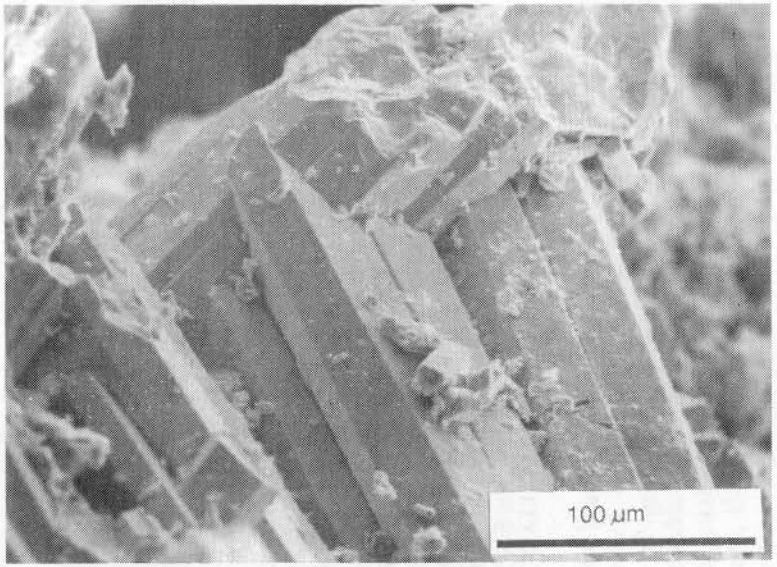

Plate 4.

Plates 1 to 4: Micrographs of pyromorphite crystals showing form, habit and hexagonal symmetry.