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Morinite from Gunheath China Clay Pit, St Austell, Cornwall

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MORINITE, $NaCa_2Al_2(PO_4)_2(OH)F_4{\cdot}2H_2O$, is a low-temperature hydrothermal phosphate found in granite and granite-pegmatite environments. It was first described by Lacroix in 1891 from Montebras, France (see Palache *et al.*, 1951) where it occurred as rose coloured prismatic crystals with amblygonite, wardite, wavellite, apatite and cassiterite. Morinite is also known from Germany, Finland (Roberts *et al.*, 1990) and the USA (Fisher and Runner, 1958; Fisher, 1960). A similar mineral, ježekite, described by Slavik in 1914 from Greifenstein, Germany, was shown to be identical with morinite (Fisher, 1962; Palache *et al.*, 1951). 'Ježekite' is also recorded from Brazil (Fisher and Runner, 1958).

Morinite has now been found in the north face of the Hensbarrow section of Gunheath China Clay Pit, near St Austell, Cornwall (NGR SX 005571). Identification was by energy dispersive X-ray analysis and X-ray diffractometry. This is the first reported occurrence of morinite in the British Isles.

At Gunheath Pit, morinite forms crusts of intergrown crystals coating the surface of a thin druse of quartz traversing partially kaolinized granite. Specimens were found on two boulders in a recent blast pile; none could be located *in situ*. The morinite crusts are coloured pale bluish-grey to grey. The colouration seems to be derived from an extremely thin layer of black copper sulphide sandwiched between colourless transparent crystals of morinite at the surface of the crusts and white, opaque-translucent, massive morinite below. Crystals are much intergrown and typically show rough faces, with subparallel growth (Fig. 1). Principal forms are {100}, {001}, {110} and {$\bar{1}$11}. Habit may be tabular to blocky, flattened on [100] or short prismatic, elongated along [010] (Fig. 2). The maximum dimension of the crystals is ~0.2 mm. These habits are distinct from those reported previously, but the rough and intergrown nature of the crystals precluded a detailed

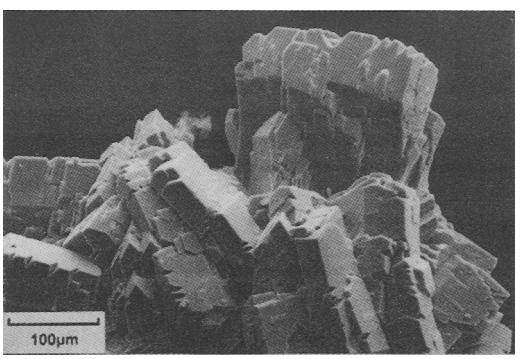

FIG. 1 Scanning electron micrograph showing intergrown crystals of morinite from Gunheath China Clay Pit, Cornwall.

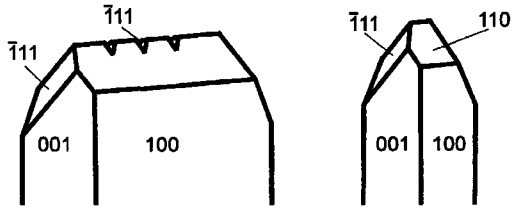

FIG. 2 Idealized crystal drawings of morinite from Gunheath Pit illustrating the two main habits.

study. Striations observed in previous occurrences (Fisher and Runner, 1958; Palache *et al.*, 1951) are absent on Gunheath morinite.

The unit cell refined from diffractometer data has $a = 9.493(2)$, $b = 10.647(4)$, $c = 5.470(1)$ Å and $\beta = 105.32(3)°$ (figures in parentheses are the standard error in the last digit). Quartz occurring naturally in the sample was used to correct for systematic errors. These values agree moderately well with those reported by Fisher and Runner (1958) and Hawthorne (1979). A semi-quantitative energy dispersive X-ray analysis (Table 1) gave a composition close to the theoretical. The structural study of morinite by Hawthorne (1979) showed little scope for OH–F substitution and suggested that the composition should be expected to be close to the ideal.

Closely associated minerals are few; occasional tabular crystals of torbernite occur on the morinite, while the granite matrix contains fluorapatite, fluorite and muscovite. A pale greenish powdery encrustation around the edges of some morinite crusts is composed largely of an intermediate member of the chalcosiderite–turquoise series. Rare dark green spheroidal dufrenite and pale brown sheaves of leucophosphite were found on other boulders in the immediate area, and crystals of libethenite occurred on drusy quartz exposed in fractured granite above the blast pile. Chalcosiderite, wavellite, cacoxenite and cyrilovite occur sporadically in iron-stained NE-trending veinlets a few tens of metres east of the morinite location. Torbernite is evidently the last formed of the phosphates, while fluorapatite appears to be the earliest, but there is no evidence to relate the relative ages of morinite and other phosphates.

Specimens of morinite from Gunheath Pit have been deposited at The Natural History Museum, London, and the University Museum, Oxford.

KEYWORDS: morinite, Gunheath, Cornwall.

TABLE 1. Chemical analysis[1] (in wt.% element) of morinite from Gunheath Pit and ideal composition

Element	Gunheath Pit[2]		Ideal composition[3]
Na	5.2	(4.6–5.8)	4.83
Ca	16.1	(15.0–16.0)	16.84
Al	11.8	(10.6–12.4)	11.33
P	14.2	(12.5–15.2)	13.01
O	37.6	(35.6–39.1)	36.97
F	14.4	(13.7–15.4)	15.96
H	–	–	1.05
Total	99.3	(96.5–102.7)	99.99

[1] Energy dispersive X-ray analysis. Accelerating voltage = 12 kV; beam current = 1.0×10^{-9} A measured on the Faraday cage.
[2] Average of eight analyses on several grains removed from one specimen. Range of analyses shown in parentheses.
[3] $Ca_2Na[Al_2F_4(OH)(H_2O)_2(PO_4)_2]$ (Hawthorne, 1979).

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