

Infra-red spectra were recorded in Nujol and hexachlorobutadiene mulls between KBr plates over the 400–4000  $\text{cm}^{-1}$  range, using a Perkin-Elmer 397 precision grating spectrophotometer, each spectrum being calibrated against polystyrene. X-ray powder diffraction photographs were taken using an IRDAB XDC 700 Guinier camera employing  $\text{Cu-K}\alpha$  radiation, the samples being mounted on adhesive tape. For the values quoted, s = strong, m = medium, w = weak, v = very, sp = sharp, sh = shoulder, br = broad.

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[Manuscript received 19 May 1982;  
 revised 1 July 1982]

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MINERALOGICAL MAGAZINE, MARCH 1983, VOL. 47, PP. 85–7

## Melanosiderite is siliceous ferrihydrite

MELANOSIDERITE was claimed to be a new mineral species by Cooke (1875). It was found in a clay bed near a serpentinite outcrop at Mineral Hill, Delaware County, Pennsylvania, and was described as a hydrated basic ferric silicate with the following average analysis:  $\text{Fe}_2\text{O}_3$  75.12,  $\text{Al}_2\text{O}_3$  4.34,  $\text{SiO}_2$  7.42,  $\text{H}_2\text{O}$  13.83, total 100.72%. The mineral is compact and brittle, has a conchoidal fracture and a vitreous lustre inclining to resinous. It is black in colour and yields a brownish red to brick red streak. Hardness is 4.5 and specific gravity is 3.39. Melanosiderite was thought to be a true silicate because of its vitreous lustre, its fusibility, its definite composition and because it gelatinizes in acids. Palache *et al.* (1944), on the other hand, state that melanosiderite is without doubt a mixture of a hydrous oxide of iron with colloidal silica or a silicate, but so far, this has never actually been proved.

A sample of melanosiderite from the type locality was kindly supplied from the British Museum (Natural History) mineral collection (BM 66908, obtained in 1891 from J. R. Gregory); its general description is in good agreement with that of the material described by Cooke. Typical shiny black fragments were examined using a Philips Debye-Scherrer camera of 11.48 cm radius with  $\text{Co-K}\alpha$  radiation. The X-ray diffraction patterns obtained from both rotated and stationary fragments consist

of eight rather broad lines that, with the exception of a broad line at 4.26 Å which can probably be attributed to goethite, are in excellent agreement with the pattern of ferrihydrite (Table I).

Frequently associated with the black melanosiderite are patches of rusty weathering material, the powder pattern of which is identical with that

TABLE I. X-ray data for (1) melanosiderite and (2) synthetic ferrihydrite

(1)		(2)	
dÅ	I	dÅ	I
4.26	40(b)	—	—
2.55	75(b)	2.54	100
2.45	20	2.46	25
2.24	100	2.24	90
1.980	30	1.977	40
1.719	30	1.727	20
1.512	40	1.512	50
1.471	60	1.469	80

- (1) Melanosiderite, shiny black fragment, Middleton, Delaware County, Pennsylvania, BM No. 66908. (b) = broad line.  
 (2) Synthetic ferrihydrite, Brown (1980).

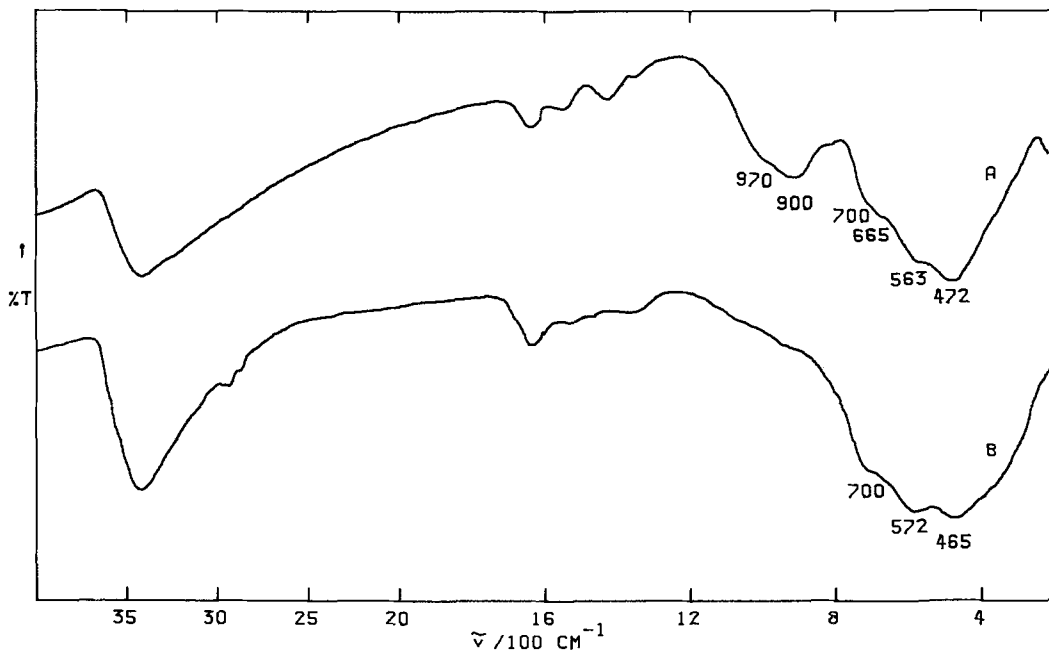


FIG. 1. Infra-red spectra of: A melanosiderite (the weak feature near  $800 \text{ cm}^{-1}$  may indicate the presence of a small amount of goethite); B synthetic ferrihydrite.

of goethite, although the spacings are slightly larger than usual.

Scanning electron microscopy revealed little morphological detail in the melanosiderite, but energy dispersive microanalysis yielded spectra dominated by iron with small amounts of silicon and aluminium. Occasional lamellar features containing Mn, Ba, Co, and Ni were observed; Mg and Cr were also present in many of the shiny black fragments examined.

The infra-red spectrum (fig. 1A) agrees well with that of synthetic ferrihydrite (fig. 1B; see also Russell, 1979), but shows additional absorption at  $970$  and  $900 \text{ cm}^{-1}$  arising from a siliceous component. The Fe-O bands of melanosiderite at  $472$ ,  $563(665)$ , and  $700 \text{ cm}^{-1}$  are, however, slightly displaced from those of the synthetic specimen which occur at  $465$ ,  $572$ , and  $700 \text{ cm}^{-1}$ . The displacement is probably due in part to the contribution of absorption in the  $400\text{--}600 \text{ cm}^{-1}$  region from the siliceous component. Infra-red spectra of natural ferrihydrite (Carlson and Schwertmann, 1981; Henmi *et al.*, 1980) also show absorption arising from a siliceous component and generally resemble that of melanosiderite although their Fe-O bands are much broader and less well resolved, and the silicate bands appear in the range  $930\text{--}85 \text{ cm}^{-1}$ . This range of frequencies is indicative of a range of states of polymerization, and possibly

structural organization, of the silicate; Carlson and Schwertmann (1981) have further shown that the frequency of the silicate band decreases to about  $925 \text{ cm}^{-1}$  following removal of the more polymerized, amorphous forms of silicate by  $1\text{M NaOH}$  at  $80^\circ\text{C}$ . This treatment similarly modifies the silicate features of melanosiderite, the inflexion at  $970 \text{ cm}^{-1}$  becoming much weaker, and the  $900 \text{ cm}^{-1}$  band narrowing and shifting to  $890 \text{ cm}^{-1}$ . The observed frequency of  $900 \text{ cm}^{-1}$  for melanosiderite, together with the general pattern of Fe-O bands with smaller half-band width, argues in favour of orthosilicate groups in well-defined (possibly surface) positions in the melanosiderite structure. As with synthetic ferrihydrite, with or without silicate, melanosiderite decomposes in a KBr pressed disc on heating to  $350^\circ\text{C}$  for 6 h.

It would appear, therefore, that the melanosiderite described by Cooke (1875) consists largely of siliceous ferrihydrite (possibly mixed with a small amount of goethite). With the evidence at his disposal, Cooke was probably quite justified in thinking melanosiderite was a new mineral species even though it is evidently not strictly a silicate. Indeed, as ferrihydrite was only approved as a distinct mineral by the International Mineralogical Association in 1971 (Chukhrov *et al.*, 1973) it is hardly surprising that the status of melanosiderite can only now be determined.

*Acknowledgements.* We are grateful to Dr A. Kato, National Science Museum, Tokyo for drawing the problem of melanosiderite to our attention and to P. G. Embrey, British Museum (Natural History) for supplying the material investigated.

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[*Manuscript received 7 April 1982*]

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MINERALOGICAL MAGAZINE, MARCH 1983, VOL. 47, PP. 87-9

## An occurrence of bavenite, $\text{Ca}_4\text{Be}_2\text{Al}_2(\text{SiO}_3)_9 \cdot x\text{H}_2\text{O}$ , in Thailand

BAVENITE is a rare beryllium mineral reported as a constituent of pegmatitic druses in granitic rocks (Claringbull, 1940; Raade, 1968), often in association with or replacing beryl (Neumann and Sverdrup, 1959; Schaller and Fairchild, 1932). The purpose of this note is to report the first occurrence of bavenite to be recognized in Thailand.

The bavenite occurs as large white crystals with a platy habit, up to 1 mm in thickness and 50 mm in length and breadth, within a skarn at the shallowly dipping contact between granite and calcareous sediments at Doi Mok scheelite mine, Wiang Pa Pao, north Thailand (Times Atlas of the World, 4th edn.). The geology of the mine has been described by Suensilpong and Jungyusuk (1981); only essential features will be repeated here. The bavenite-bearing skarn forms the top of a small hill separated from more extensive hills by a deep fault gulley and marble cliffs. Gradation from the skarn into the country rocks is consequently not seen because of the faulting, but the skarn-granite contact is well exposed in mine workings.

The mineralogy of the skarn and immediately adjacent granite is complex. In thin section, the bavenite occurs as euhedral laths with rectangular cross-sections, showing moderately high relief ( $\alpha = 1.586$ ;  $\beta = \gamma = 1.590$ ; Switzer and Reichen, 1960) and set in massive hydrogrossular and interstitial calcite. Individual crystals of bavenite are fractured and cemented by calcite. Epidote occurs as needles within calcite, and scheelite is present. Although

not observed in the bavenite-bearing material, idocrase, chlorite, plagioclase, diopside, and quartz are also reported to be present within the skarn (Suensilpong and Jungyusuk, 1981).

Two facies of granite are exposed in the mine workings: an early biotite granite, which is cut by veins of a later tourmaline leucogranite. Both varieties show varying degrees of hydrothermal alteration in irregularly spaced zones cut by the mine levels. Where the alteration is relatively slight, sericitization of both alkali feldspar and plagioclase is observed, and biotite (if present) is altered to chlorite containing needles of rutile. The tourmaline leucogranite shows recrystallization of tourmaline as small needles as well as sericitization of the feldspars. Both granite varieties show more severe effects of alteration within approximately 10 m of the contact, where calcite and fluorite occur as cross-cutting veins and as matrix to altered silicate minerals (which include sericitic pseudomorphs after feldspar). In this contact zone the rutile inclusions within chlorite pseudomorphs after biotite are replaced by sphene. The presence of sphene, and calcite veining, is also observed in alteration zones further from the contact; these may not be far below the roof of the granite.

Standard X-ray diffraction methods (scanning goniometer, with Al as an internal standard and monochromator-resolved  $\text{Cu-K}\alpha_1$  radiation) were used to characterize the bavenite from Doi Mok. The orthorhombic cell parameters are:  $a = 9.72$