

## SHORT COMMUNICATIONS

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### Niahite—a new mineral from Malaysia\*

A NEW mineral niahite,  $\text{NH}_4(\text{Mn}^{2+}, \text{Mg}, \text{Ca})\text{PO}_4 \cdot \text{H}_2\text{O}$ , is found as fine radiating and sub-parallel clusters of crystals up to 0.5 mm in size in soft, fine-grained newberyite,  $\text{MgHPO}_4 \cdot 3\text{H}_2\text{O}$ , in the Niah Great Cave, Sarawak, Malaysia. It is closely associated with what appears to be a 'gypsum variant', collophane, hannayite, struvite, variscite, and an unidentified zinc potassium phosphate, all derived from the breakdown of guano. Other associated minerals are gypsum, brushite?, vivianite, ardealite, and variants, strengite, monetite, whitlockite, leucophosphite, taranakite, opal, and quartz.

A chemical analysis of niahite was obtained by means of a combination of electron probe micro-analysis using analysed apatite (for Ca and P), MgO, and pure Mn as standards, and microchemical methods (for N, H, and P). The following figures were obtained:  $(\text{NH}_4)_2\text{O}$  12.9, MnO 27.21, MgO 4.19, CaO 1.99,  $\text{P}_2\text{O}_5$  37.83,  $\text{H}_2\text{O}$  11.88, total 96.00%. This yields the empirical formula  $(\text{NH}_4)_{0.93}(\text{Mn}^{2+}_{0.72}\text{Mg}_{0.20}\text{Ca}_{0.06})_{20.98}\text{P}_{1.00}\text{O}_{3.95} \cdot 1.23 \text{H}_2\text{O}$  on the basis of P = 1.

Single crystal X-ray studies could not be made due to the very soft and fragile nature of niahite, but the X-ray powder pattern is very close to that of  $\text{NH}_4\text{MgPO}_4 \cdot \text{H}_2\text{O}$  in pattern 20-663 in the JCPDS Powder Diffraction File, and similar to  $\text{NH}_4\text{MnPO}_4 \cdot \text{H}_2\text{O}$ , JCPDS pattern 3-0027. The strongest lines in the X-ray powder pattern are given in Table I. The pattern can be indexed on an orthorhombic unit cell with  $a$  5.68,  $b$  8.78,  $c$  4.88 Å, and  $Z = 2$ . The  $(hkl)$  indices satisfy the extinction rule for space group  $Pmn2_1$ .  $\text{NH}_4\text{MgPO}_4 \cdot \text{H}_2\text{O}$  of Mrose (1971) has the same space group and  $a$  5.606,  $b$  8.758,  $c$  4.88 Å.

Optically niahite is biaxial negative with  $2V = 54^\circ$  (measured) and  $50^\circ$  (calculated). Its refractive indices are  $\alpha = 1.582(2)$ ,  $\beta = 1.604(2)$ ,  $\gamma = 1.609(2)$ . It has a pale orange colour and white streak, but is colourless in thin section. The measured density is  $2.39 \text{ g/cm}^3$  and the calculated value is  $2.437 \text{ g/cm}^3$ .

\* Mineral and name approved by the IMA Commission on New Minerals and Mineral Names.

TABLE I. X-ray powder data for niahite

$hkl$	$d_{\text{obs.}}$ (Å)	$I_{\text{obs.}}$	$d_{\text{calc.}}$ (Å)
010	8.82	10	8.785
110	4.79	5	4.773
011	4.267	6	4.268
111	3.412	4	3.413
200	2.845	8	2.843
121	2.832	9	2.832
031	2.513	3	2.511
002	2.437	3	2.442
211	2.367	3	2.366
131	2.300	4	2.297
221	2.146	3	2.144

With a further 20 lines to 1.259 Å. Guinier focusing camera, Cu-K $\alpha$  radiation.

Niahite is therefore the manganese analogue of the artificial compound  $\text{NH}_4\text{MgPO}_4 \cdot \text{H}_2\text{O}$  described by Frazier *et al.* (1966), and the name is proposed for material with  $\text{Mn}^{2+} > (\text{Mg} + \text{Ca})$ . This compound was correlated with ditmarite by Mrose (1971), but an examination of analyses in McIvor (1902) shows that this conclusion is doubtful. Type specimens have been deposited in the collections of the West Australian Government Chemical Laboratories, the Malaysian Geological Survey in Kuching, and the Bureau of Mineral Resources, Canberra.

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## Mundrabillaite—a new cave mineral from Western Australia

IN an earlier contribution (Bridge, 1977) on minerals from the Petrogale Cave, Western Australia, naturally occurring  $(\text{NH}_4)_2\text{Ca}(\text{HPO}_4)_2 \cdot \text{H}_2\text{O}$  was reported. A full characterization of this mineral has now been carried out and the name mundrabillaite has been approved by the IMA Commission on New Minerals and Mineral Names. The mineral is found in Petrogale Cave, 36 km east of Madura Motel ( $31^\circ 54' \text{ S}$ ,  $127^\circ 00' \text{ E}$ ), Western Australia, as tiny crystals in association with archerite, biphosphammite, apthitalite, halite, syngenite, stercorite, oxammite, weddellite, whitlockite, guanine, newberyite, calcite, and an unknown phosphate. The name is for the nearby pastoral lease, Mundrabilla Station.

An average of nine electron probe analyses using analysed fluorapatite as the standard gave CaO 20.4,  $\text{P}_2\text{O}_5$  48.6%. The analyses also showed  $\text{K}_2\text{O}$  1.09–0.60 (av. 0.85),  $\text{Fe}_2\text{O}_3$  (total Fe) 0.08–0.02 (av. 0.05),  $\text{SO}_3$  0.04(av.), and MgO 0.04%(av.). K and Fe were present in all the analyses and Mg and S in half of them. Chemical tests for  $\text{NH}_3$  and  $\text{H}_2\text{O}$  were positive, but no quantitative determination was possible due to the scanty supply of high-purity material. From the above analyses and the result of the X-ray powder diffraction study, the ideal formula is given as  $(\text{NH}_4)_2\text{Ca}(\text{HPO}_4)_2 \cdot \text{H}_2\text{O}$ , which requires  $(\text{NH}_4)_2\text{O}$  18.20, CaO 19.60,  $\text{P}_2\text{O}_5$  49.61,  $\text{H}_2\text{O}$  12.59%. A part of the  $\text{NH}_4$  is replaced by K and the material is therefore a potassian mundrabillaite.

An X-ray single crystal study could not be carried out owing to the very soft and fragile nature of mundrabillaite. However the X-ray powder diffraction pattern can be indexed on a monoclinic

TABLE I. X-ray powder diffraction data for mundrabillaite

<i>hkl</i>	$d_{\text{obs.}} \text{ \AA}$	$I_{\text{obs.}}$	$d_{\text{calc.}} \text{ \AA}$
100	8.60	3	8.559
200	4.279	10	4.279
120	3.687	4	3.692
102 } 211 } 121 }	3.106	6	3.111
112 } 300 } 102 }	2.873	3	2.916 2.853 2.85
030	2.728	2	2.728
003	2.116	$1\frac{1}{2}$	2.116

With a further 23 lines observed.  
 Co-K $\alpha$  radiation, Debye-Scherrer camera, 11.5 cm diameter.

cell with  $a$  8.643,  $b$  8.184,  $c$  6.411 Å,  $\beta$  98.0°,  $Z = 2$ . The strongest lines in the X-ray powder pattern are given in Table I. From the (*hkl*) indices obtained, the possible space groups are *Pm*, *P2*, or *P2/m*, provided that the material is monoclinic and not triclinic with  $\alpha = \gamma = 90^\circ$  (A. Kato, pers. comm.). The data are very similar to those for synthetic  $(\text{NH}_4)_2\text{Ca}(\text{HPO}_4)_2 \cdot \text{H}_2\text{O}$  (Frazier *et al.*, 1964; PDF Card 20-0203).

Mundrabillaite is colourless with an earthy lustre and white streak. Its hardness is very low and it