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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						
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  $\text{\AA}$ ,  $\beta$  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

is fragile. The specific gravity of synthetic material has been measured as 2.05; calculation from the unit cell contents gives 2.09 and from Gladstone-Dale's Law, 2.00. The synthetic material forms stout rods elongated along  $c$  and with prominent {110}. The mineral is soluble in water. It is optically biaxial negative,  $2V$   $61^\circ$ (calc.), refractive indices  $\alpha$  1.522(2),  $\beta$  1.544(2),  $\gamma$  1.552(2); extinction oblique, angle  $+26(1)^\circ$ . Synthetic material is also biaxial negative,  $2V$   $65^\circ$ (obs.),  $66^\circ$ (calc.),  $\alpha$  1.521,  $\beta$  1.542,  $\gamma$  1.551;  $b = X$ ,  $c \vee Y = +25^\circ$ . It is colourless under the microscope.

$(\text{NH}_4)_2\text{Ca}(\text{HPO}_4)_2 \cdot \text{H}_2\text{O}$  is dimorphic and mundrabillaite is referred to as form-A. Form-B is also monoclinic but this phase is not present in the mundrabillaite specimens examined. This was con-

firmed by the X-ray powder pattern and optical examination following reference to PDF Card 20-0204.

Type specimens of mundrabillaite are preserved in the Government Chemical Laboratories mineral collection as MDC 5906.

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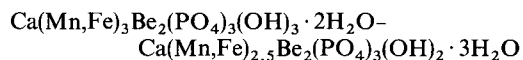
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## Iron-rich roscherite from Gunnislake, Cornwall

ROSCHERITE, a monoclinic hydrous phosphate of Ca, Mn, Fe, and Be, has so far been recorded from about half a dozen occurrences, usually in phosphate pegmatites. Originally described by Slavik (1914), it was not until the work of Lindberg (1958) that the presence of essential Be in the mineral was recognized. Subsequent crystal structure work by Fanfani *et al.* (1977) has shown that a triclinic modification of roscherite exists, occurring when the mineral has a significant trivalent metal content. Their work suggests that the normal monoclinic roscherite, containing only divalent metals, should have a formula in the series



The major isomorphous substitution is therefore that of Mn by Fe, although replacement of Mn by Mg is noted in one specimen (Fanfani *et al.*, 1975). Al occurs in minor amounts as the principal trivalent substitution.

Lindberg (1958) has recorded a roscherite from the Nevel Quarry, Newry, Maine, with an Fe:Mn ratio approaching 2:1, and this has remained the highest iron figure obtained for the mineral. However, the recent discovery of roscherite in cavities

in the granite at Gunnislake, Cornwall, reported in this paper, provides examples of virtually end-member iron-bearing material. Lindberg (1958) suggested that the name roscherite should apply to all members of the structural group irrespective of the degree of Ca-Mn-Fe substitution (it is now known that Ca does not contribute to isomorphous substitution in the mineral). Despite the extreme Fe content recorded for this roscherite, it does not, on the basis of Lindberg's definition, warrant a new name.

*Occurrence.* This Fe-rich roscherite has been found at the Clitters United Mine (also known as Gunnislake Clitters), in Calstock Parish in Cornwall, on a steep hillside overlooking the river Tamar. The mine operated mainly during the last century on E.-W. trending lodes, close to the killas contact, carrying copper, tin, arsenic, and tungsten. It was amalgamated with the Hingston Down Mine towards the end of the nineteenth century, and finally ceased operations in 1919.

The main lode at Clitters United Mine was worked from Skinners Engine Shaft, the collar of which was just below the road from Gunnislake to Chilsworthy at GR 422719 ( $2\frac{1}{2}''$  OS map SX 47). There are large dumps on the hillside below the