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Note: Swaknoite ($Ca(NH_4)_2 (HPO_4)_2.H_2O$, orthorhombic), a new mineral from Arnhem Cave, Namibia

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Introduction

During a caving expedition in Namibia in February 1990, the author and Eugene Marais of the State Museum in Windhoek, visited Arnhem Cave in order to collect minerals and to study the geology. Arnhem Cave is the longest in Namibia and is situated approximately 150 km to the east of Windhoek. One sample yielded an unidentified mineral which had a X-ray diffraction pattern and a chemical composition identical to a substance synthesised by Frazier *et al.* (1964). Therefore it was a new species as it had not been reported in nature. The mineral has been approved by the Commission on New Minerals and Mineral Names of the International Mineralogical Association.

Physical Properties

Swaknoite forms very thin needles, up to 1 mm long and a few 10 microns wide, often grouped in rosettes. The colour is white and the lustre vitreous. The hardness could not be measured because of the fine grain size, but the mineral seems soft and brittle. The density is 1.91 g/cm^3, measured by "float and sink" in a mixture of tetrabromoaethane and acetone. The density calculated after the unit cell is 1.89 g/cm^3. The mineral is incongruently soluble in water.

Optical Properties

The mineral is biaxial negative: α = 1.506, ß = 1.510, γ = 1.512. 2V (measured) = 65° (± 10), 2V (calculated) = 70º. It.is colourless, with no detectable dispersion.

The orientation is X = b, Y = a, Z = c.

Chemical Data

Ca and P were determined by microprobe at the Geological Survey in Pretoria and H and N by gaz chromatography at the National Chemical Laboratory in Pretoria. The analyses gave the following results:

$(NH_4)_2O$	=	16.06
CaO	=	21.46
P_2O_5	=	48.93
H_2O	=	12.78
Total	=	99.23%

This yields the empirical formula (based on 0 = 9):

$$Ca_{1.10} (NH_4)_{1.78} (PO_4)_{1.99} . 1.05\ H_2O$$

The ideal formula is:

$$Ca\ (NH_4)_2\ (PO_4)_2 .\ H_2O$$

Crystallography

Due to the very fine and brittle nature of the mineral, no needle could be mounted for X-ray single crystal study. Longer, but extremely thin crystals were synthesised by the author, from which a rotation fibre diagram

I	d measured	d calculated	hkl
57	10.5	10.48	200
100	6.99	6.98	110
2	5.51	5.51	201
21	5.24	5.24	400
8	5.09	5.081	310
36	4.739	4.748	111
21	3.994	3.998	311
89	3.705	3.702	020
39	3.651	3.648	510
10	3.490	3.490	220
8	3.212	3.214	021
55	3.177	3.178	511
7	3.082	3.075	601
19	3.028	3.023	420
7	2.743	2.740	421
7	2.727	2.731	312
4	2.437	2.438	022
5	2.421	2.421, 2.422	122,512
9	2.369	2.365	621
5	2.330	2.329	900
4	2.294	2.292	131
11	2.192	2.192, 2.190,2.19	901, 331, 721
14	2.131	2.127	530
16	2.101	2.101	911
8	2.034	2.037, 2.031	802, 821
9	2.024	2.021	531
5	1.987	1.987	313
2	1.890	1.890, 1.891	722, 902
7	1.828	1.827	731
3	1.785	1.785, 1.783	822, 613
7	1.756	1.757, 1.754	423, 241
4	1.641	1.642	732

Table 1: Swaknoite, powder diffraction pattern

could be obtained and an orthorhombic unit cell could be derived:

a = 20.959; b = 7.403; c = 6.478Å; Z = 4

The X-ray diffraction powder diagram, obtained with a diffractometer, CoKα radiation, is presented in Table 1.

Although the needles are very fine, forms could be observed under the microscope (Fig. 1): {110} (ubiquitous), {100} (frequent, {111} (seldom observed), {001} (observed, but is possibly a cleavage).

The a:b:c ratios could be measured approximately as 2.85:1:0.90, which confirm the ratios obtained from the unit cell: 2.8311:1:0.8751.

The crystallographic data, based on morphology only, given by Frazier *et al.* (1964) differ from the data presented here, although the X-ray pattern and the chemistry are identical with the material these authors synthesised. They proposed a monoclinic symmetry. For this reason this author first proposed a monoclinic cell, but a member of the commission pointed out that this cell could be transformed into an orthorhombic cell, which fits better with the other properties of the mineral. It is possible that the crystallographical data presented by Frazier *et al.* (1964) are erroneous due to the extremely fine nature of their material.

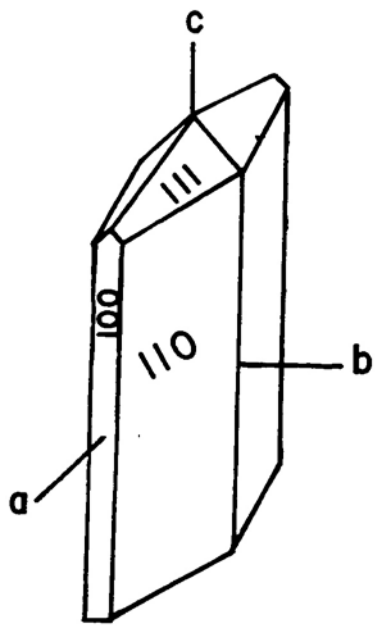

Figure 1: Swaknoite

Paragenesis and genesis

The mineral occurs as a white coating on the dolomite walls of the cave, associated with mundrabillaite, the monoclinic polymorph of swaknoite (Bridge and Clarke, 1983) forming shiny hyaline prisms up to 5 mm long, with dittmarite ($NH_4MgPO_4.H_2O$) forming a microcrystalline chalky material, and with arcanite (K_2SO_4) forming micaceous plates up to 1 cm across. Swaknoite derives from the decay of bat guano producing NH_3 and PO_4H_3, reacting with the walls containing Ca.

Name and type material

The name is derived from Suid Wes Afrika Karst Navorsing Organisasie (SWAKNO), the spelaeological association which explored Amhem Cave, and noticed that the cave was rich in minerals. Type material is deposited at the Geological Survey, Windhoek, Namibia and in the Transvaal Museum in Pretoria.

Acknowledgements

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References

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Frazier, A.W., Lehr, J.R. and Smith, J.P. (1964) Calcium ammonium orthophospahte. *J. Agr. Food Chem.*, **12**, 198-201.