Gwihabaite - $(NH_4,K)NO_3$, Orthorhombic

A New Mineral From Gcwihaba Cave, Botswana

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Introduction

During a speleological expedition in NW Botswana, organised by the South West Africa Karst Research Organisation, the author conducted a systematic mineralogical investigation of Gcwihaba Cave. It is also known as Drotsky's Cave, after the first European who visited it in 1932[1], and is the longest in Botswana[2]. It is developed in a small dolomite hill protruding from the sand of the uniformly flat Kalahari basin. It is located 280 km. to the west of Maun and is accessible only by four wheel drive vehicles. One sample yielded an unidentified mineral which proved to be a new species. The mineral has been approved by the Commission on New Minerals and Mineral Names of the International Mineralogical Association. Gwihabaite is a species chemically intermediate between nitre (KNO_3) and nitrammite ($(NH_4)NO_3$), and contributes to a better understanding of the nitrate minerals of this group.

Physical Properties

Gwihabaite occurs as slender needles and oulopholites, up to 5 mm. long, forming efflorescences on the walls, boulders, bat guano and earthy floor of the cave. It is also present in saline crusts coating boulders, where it is finely crystallised and mixed with gypsum, syngenite, boussingaultite and dittmarite. It is colourless, vitreous and transparent. The hardness seems close to 2; there is no cleavage. The mineral is very soluble in water and deliquescent in humid atmosphere. The density is 1·77 g/cm_3, measured by "float and sink" in a mixture of tetrabromoethane and acetone. The density calculated after the unit cell is 1·79 g/cm^3.

Optical Properties

The mineral is biaxial negative: α = 1·458, β = 1·527, γ = 1·599 2V (measured) = 90°, 2V (calculated) = 87°. It is colourless with no detectable dispersion. The orientation is X = b, Y = a, Z = c.

Chemical Data

N and H were determined by gas chromatography in the laboratories of the Council for Scientific and Industrial Research; and K was analysed by X-ray fluorescence in the laboratory of the Council for Geoscience, both in Pretoria. The results are:

$(NH_4)_2O$	= 25·09
K_2O	= 10·40
N_2O_5	= 61·41
Total	= 98·90%

This yields the empirical formula, based on O=3 :

$$[(NH_4)_{0.81}\ K_{0.19}]_{\Sigma 1.00}\ (NO_3)_{1.00}$$

The simplified formula is:

$(NH_4,K)\ NO_3$

Crystallography

The X-ray diffraction lines were indexed after rotation patterns of single crystals, and gave the following cell parameters, refined from powder data (Table 1):

Orthorhombic (Pbnm),
a = 7·075, b = 7·647, c = 5·779, Z = 4.

The crystals are acicular and elongated, parallel to [001] and the forms are {110}, {100}, {111}.

Genesis

The mineral derives from the bacterial decay of bat guano, which provides ammonium and nitrate. Potassium is probably also from guano. It crystallises by evaporation due to the very dry climate of the cave.

Synthesis, Stability Domains and Relations to Known Species

Gwihabaite can be synthesised at 25°C by evaporating a solution containing ammonium and potassium nitrates in the proportion indicated by the formula. Preliminary experiments at room temperature showed that from solutions containing approximately less than 0·05 mK/mK + m NH_4, nitrammite crystallises. Between 0·05 and 0·2, gwihabaite is the single phase to form. From 0·2 to 0·65 gwihabaite forms, but associated with a rhombohedral phase, which becomes predominant when K increases. This rhombohedral phase is probably a K-NH_4 nitrate and is isomorphic with the high-tempera-ture rhombohedral polymorph of KNO_3. Between 0·65 and 0·9, nitre and the rhombohedral phase crystallise. Above 0·9, only nitre forms.

Gwihabaite is isomorphic with synthetic $(NH_4)NO_3$, form III (Table 2), which is stable only above 32·3°C. From experiments it appears that the presence of K, in solid solution in NH_4NO_3 lowers the stability temperature of form III. The experiments also suggest that at room temperature, the minimum range of

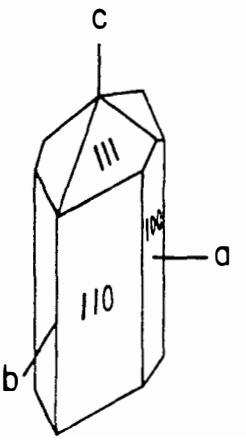

Fig 1: Morphology of gwihabaite

X-RAY DIFFRACTION PATTERN

I	d meas	d calc	hkl
5	5·19	5·193	110
10	4·477	4·476	101
75	3·863	3·863	111
5	3·535	3·538	200
85	3·364	3·364	120
95	3·212	3·211	210
100	3·194	3·189	021
30	2·905	2·907	121
10	2·886	2·889	002
35	2·805	2·807	211
90	2·595	2·597	220
5	2·523	2·525	112
50	2·400	2·398	130
5	2·369	2·369	221
20	2·305	2·305	022
15	2·250	2·254	310
20	2·236	2·238	202
5	2·214	2·215	131
5	2·191	2·192	122
2	2·068	2·068	230
2	2·007	2·007	320
2	1·930	1·931	222
2	1·914	1·912	040
2	1·895	1·896	321
5	1·804	1·806	113
5	1·758	1·758	141
5	1·720	1·720	023
2	1·682	1·682	240
5	1·650	1·652; 1·649	213; 411; 322
5	1·615	1·615	241

Table 1

K in the formula is between 0·05 and 0·2. It is also predictable that nitrammite should not occur frequently in nature, since an unusually low K environment, preferably cold, is required and that gwihabaite should be the most common form of ammonium nitrate.

Name and Type Material

The name is after Gcwihaba Cave, but had to be altered by removing the "c" to make it conform to the rules of the International Mineralogical Association. In the correct pronunciation "G" is for the click sound of the San language. Type material is deposited in the Transvaal Museum in Pretoria.

References

1 Cape Argus 10 Sep. 1932 p. 13.

2 Cooke H.J. & Baillieul T. (1974) "The Caves of Ngamiland: An Interim Report on Explorations and Fieldwork 1972-74" *Botswana Notes and Records 6.* 147-156.

Comparison Between Gwihabaite, NH_4NO_3 (iii) & Nitrammite

GWIHABAITE			NH_4NO_3 III (ASTM 8-499)			NITRAMMITE		
$(NH_4,K)NO_3$ Orthorhombic			NH_4NO_3 Orthorhombic Pbnm			NH_4NO_3 Orthorhombic Pnmm		
a = 7·075			a = 7·18			a = 4·942		
b = 7·647			b = 7·71			b = 5·438		
c = 5·779			c = 5·83			c = 5·745		
Z = 4		Z = 4				Z = 2		
α = 1·458			---			α = 1·411		
β = 1·527			---			β = 1·612		
γ = 1·599			---			γ = 1·635		
+2V = 87°			---			-2V = 35°		
dÅ	I/I_{100}	hkl	dÅ	I/I_{100}	hkl	dÅ	I/I_{100}	hkl
5·19	5	110	5·34	10	110	4·95	45	110
4·477	10	101	4·55	20	101	3·96	65	011
3·863	75	111	3·91	55	111	3·66	2	110
3·535	5	200	-	-	-	3·08	100	111
3·364	85	120	3·40	70	120	2·879	10	002
3·212	95	210	3·25	90	210	2·722	75	020
3·194	100	021	3·22	30	021	2·485	10	102
2·905	30	121	2·938	12	121	2·380	8	120
2·886	10	002	2·910	6	002	2·260	45	112
2·805	35	211	2·846	40	211	2·249	2	210
2·595	90	220	2·635	100	220			
2·523	5	112	2·554	8	112			
2·400	50	130	2·421	35	130			
2·369	5	221	-	-	-			
2·305	20	022	2·331	18	022			
2·250	15	310	2·291	35	310			
2·236	20	202	2·268	45	202			

Table 2