STUDIES OF URANIUM MINERALS (III): SALÉEITE FROM SCHNEEBERG, SAXONY*

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ABSTRACT

Saléeite from Schneeberg, Saxony, has the composition $Mg(UO_2)_2(P,AsO_4)_2 \cdot 10H_2O$, with P:As=84.4:18.8, and is isostructural with fully hydrated artificial autunite, $Ca(UO_2)_2(PO_4)_2 \cdot 10H_2O$. Crystals are flat tablets on {001} with {010} and {012} and are found by *x*-ray and optical study to be tetragonal. Unit cell dimensions: $a_0=6.890$ Å, $c_0=19.813$ ($a_0:c_0=1:2.839$; $a:c=1:2.840$ morphology), with the space group, if holohedral, *I4/mmm*. Specific gravity 3.27 (meas.), 3.27 (calc. for two formula-units per cell). Color yellow to lemon-yellow. Perfect cleavage {001}. Optically uniaxial negative with *n*O 1.574 (pale yellow), *n*E 1.559 (nearly colorless). The original saléeite from Katanga has the composition $Mg(UO_2)_2(PO_4)_2 \cdot 8H_2O$ and appears from the available evidence to be a lower hydrate that is isostructural with meta-autunite-I.

INTRODUCTION

In the course of a study of natural and artificial uranospinite, $Ca(UO_2)_2(AsO_4)_2 \cdot 10H_2O$, a specimen from the Weisser Hirsch mine, Schneeberg, Saxony, was examined in some detail in the belief that it was this species, on the basis of apparent similarity in crystallography and optics. Later, on chemical analysis, the mineral was found to be the Mg analogue thereof and hence to be saléeite, $Mg(UO_2)_2(PO_4)_2 \cdot 10H_2O$. Although the writer was unable to obtain an authentic specimen of saléeite from Katanga for direct comparison, the identity of the Schneeberg mineral therewith appears to be certain.

Saléeite from Katanga, Belgian Congo. The mineral saléeite was originally found at Chinkolobwe, Katanga, in the Belgian Congo, and was first described by J. Thoreau and J. F. Vaes in 1932. The mineral occurred there in a siliceous rock associated with the uranium phosphates torbernite and dewindtite. A chemical analysis (Table 3) on a 400 mg. sample indicated the formula of the mineral to be $Mg(UO_2)_2(PO_4)_2 \cdot 8H_2O$. Saléeite from this locality was described as small, thin, rectangular plates up to 2 mm. on edge, usually grown in parallel position with torbernite. Color lemon-yellow. Cleavages {001} perfect, also {100} and {010}; hardness 2–3; specific gravity a little below 3.3. The optical data are given in Table 1. On the basis of the biaxial optical character Thoreau and Vaes (1932) considered saléeite to be orthorhombic, but possessing pseudo-tetragonal symmetry. On the basis of measurements made under the microscope the crystal forms present were stated to be {001}, {010}, {100}, {120}, and {210}, with {001} as the plane of flattening

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and perfect cleavage, but an axial ratio was not given. Crystals resting on {001} when viewed in polarized light showed a division into two or four sectors, with the axial planes therein at right angles and parallel to the edges of the square plates, which was interpreted as due to twinning by pseudo-merohedry on [001]. (This feature also may be due to inversion into a lower hydrate isostructural with meta-autunite-I as discussed beyond.) Schoep (1939) later considered the mineral to be monoclinic, with the plane of flattening and perfect cleavage as {010}, and the twinning as on {$\bar{2}$01}, on the basis of etch effects and apparent differences in the ease of cleavage in different directions. This evidence, however, is inconclusive. Autunite thus has been considered to be monoclinic on similar evidence, but the symmetry of the etch figures has been shown to depend on the conditions of etching and the biaxial character to be related to the content of zeolitic water; the *x*-ray structural study of this mineral proves it to be strictly tetragonal.

Table 1. Optical Properties of Saléeite

	Saléeite Schneeberg (Mrose, 1949, on analyzed material)	Saléeite Katanga (Thoreau and Vaes, 1932)
Sign	(−)	(−)
Indices:		
*n*X or E	1.559±0.002	1.559
*n*Y		1.570
*n*Z or O	1.574±0.002	1.574
Opt. Orient.		X=*b*, Y∼*c*, Z∼*a**
Dispersion		*r*>*v*, marked
Pleochroism		
X or E	nearly colorless	
Y		
Z or O	pale greenish yellow	
2V (meas.).	0°	61°00′
2V (calc.)		61°49′

* Orientation of Schoep (1939), who made the crystals monoclinic from a study of etch figures and cleavages.

Saléeite from Schneeberg, Saxony. Saléeite was identified in this study from material on a specimen (Harvard no. 101126) from Schneeberg erroneously labelled uranospinite. This locality is new for the species. The mineral occurs both as small doubly-terminated rectangular crystals and as interlocking rectangular plates, ranging from ½ mm. up to 1 mm. on edge, in a limonite-rich rock associated with uranophane and zeunerite. Most of the crystals are opaque. The color varies from lemon-yellow to yellow with a greenish tint. There is a perfect cleavage on {001}. The hardness is 2–3. The specific gravity was determined for both single crystals and cleavage fragments on the microbalance as 3.27. This value is in exact agreement with the calculated specific gravity for the unit cell contents. The quantitative analysis by F. A. Gonyer on this material, cited in Table 3, proved it to have the composition $Mg(UO_2)_2(P,AsO_4)_2 \cdot 10H_2O$ with P:As = 84.4:18.8. The data cited in Table 1 indicate close optical agreement with material from Katanga. The *x*-ray powder diffraction spacings are cited in Table 4. The mineral fluoresces a bright lemon-yellow in long-wave ultraviolet radiation and pale yellow in short-wave ultraviolet radiation.

CRYSTALLOGRAPHY AND SYMMETRY

The saléeite from Schneeberg occurs as small doubly-terminated crystals most of which are too rough to afford accurate goniometric measurements. Several crystals provided approximate measurements which indicated the forms present to be *c*{001}, *a*{010} and *e*{012}.

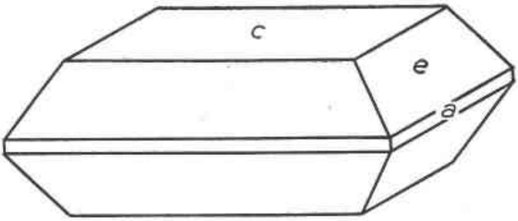

FIG. 1. Saléeite crystal from Schneeberg, Saxony.

An average of the best measurements gave 54° 51′ for {001}∧{010} indicating it to be the form {012}. This is in close agreement with the calculated value based on the *x*-ray elements. An average of the measured angles tabulated below give the ratio *a*:*c* = 1:2.840 which is in agreement with that derived from *x*-ray study.

	ϕ	ρ
c 001	0°00′	—
a 010	0°00′	90°00′
e 012	0°00′	54°51′

An angle table based on the elements derived from *x*-ray study for forms observed on Schneeberg and Katanga crystals is given in Table 2.

The crystals proved suitable for single-crystal *x*-ray work. The following data were obtained by the precession method using molybdenum radiation:

$a_0=6.980$Å. Possible space groups: $I\bar{4}2m$, $I\bar{4}m2$, $I4mm$, $I42$, or $I4/mmm$. $c_0=19.813$; $a_0:c_0=1:2.839$ (*x*-ray cell)

Cell contents: $2[Mg(UO_2)_2(P, AsO_4)_2 \cdot 10H_2O]$

If the crystal class is taken to be ditetragonal dipyramidal, as indicated by the form development and crude goniometric measurements, the space group is established by the diffraction effects as $I4/mmm$. The *x*-ray data conclusively establish the Schneeberg saléeite as tetragonal, in contradiction to the orthorhombic symmetry assigned to the Katanga material by Thoreau and Vaes (1932) and the monoclinic symmetry assigned it by Schoep (1939).

TABLE 2. SALÉEITE: ANGLE TABLE

Tetragonal; ditetragonal-dipyramidal—$4/m\ 2/m\ 2/m$

$a:c=1:2.839$; $p_0:r_0=2.839:1$

	ϕ	ρ	A	$\overline{M}$
c 001	—	0°00′	90°00′	90°00′
a 010	0°00′	90 00	90 00	45 00
d 120	26 34	90 00	63 26	71 34
e 012	0 00	54 50	90 00	54 41

CHEMISTRY

A chemical analysis of the Schneeberg saléeite, cited in column 4 of Table 3, indicates the formula of the mineral to be $Mg(UO_2)_2(P,AsO_4)_2$

TABLE 3. CHEMICAL ANALYSES OF SALÉEITE

	1	2	3	4
MgO	4.49	5.01	4.31	4.31
UO_3	63.67	64.07	61.23	60.32
P_2O_5	15.80	14.44	15.19	11.98
As_2O_5				4.50
H_2O	16.04	16.48	19.27	[18.89]
Total	100.00	100.00	100.00	[100.00]
G		<3.3		3.27

1. $Mg(UO_2)_2(PO_4)_2 \cdot 8H_2O$.
2. Saléeite. Katanga, Belgian Congo. M. Mollet analyst, in Thoreau and Vaes (1932). Recalculated to 100 after deduction of 2.79 per cent insoluble.
3. $Mg(UO_2)_2(PO_4)_2 \cdot 10H_2O$.
4. Saléeite. Schneeberg, Saxony. F. A. Gonyer analyst, June, 1949.

$\cdot 10\ H_2O$ with P:As = 84.4:18.8. A spectrographic analysis on the same material in the spectral range between 2200 Å and 4300 Å showed that the minor constituents and traces included *Ca*, *Pb*, *V*, *Bi*, *Cu* and *Ag*.

The saléeite from Katanga differs in formula from the Schneeberg material by the absence of As_2O_5 and by having a water content of $8H_2O$ rather than $10H_2O$. The water content doubtless varies at ordinary temperatures with the humidity as it does with the isostructural minerals torbernite, autunite and zeunerite.

The *x*-ray powder pattern of the Schneeberg saléeite is virtually identical with that of fully hydrated synthetic autunite, $Ca(UO_2)_2(PO_4)_2 \cdot 10\ H_2O$, as described by Beintema (1938), and differs from that of the lower hydrates meta-autunite-I with $6\frac{1}{2}(?)H_2O$ and meta-autunite-II with 0 to $6H_2O$. The water content of these hydrates is partly zeolitic and the indices of refraction and 2V vary therewith. Meta-autunite-I is structurally tetragonal but optically it is uniaxial or biaxial, with 2V from 0° to 53° depending on the water content. The rectangular plates are divided into four biaxial segments each with its optic plane parallel to the edge of the plate. This mosaic character and optical orientation also are found in the Katanga saléeite and since this mineral has a relatively low water content it may correspond to meta-autunite-I; in such a case, the name meta-saléeite would be appropriate for this material and the name saléeite proper could be restricted to the Schneeberg material here described.

TABLE 4. *X*-RAY POWDER SPACING DATA ON ANALYZED SALÉEITE FROM SCHNEEBERG
Copper radiation, nickel filter (in Å)

No.	*I*	*d* (meas.)	No.	*I*	*d* (meas.)
1	10	9.94	12*	3	3.34
2	5	8.76	13	3	3.12
3	3	7.90	14	2	2.99
4	3	6.61	15	3	2.89
5	1	5.91	16	3	2.49
6	1	5.47	17*	3	2.23
7	8	5.01	18	2	2.00
8*	3	4.42	19	1	1.86
9	1	3.95	20	1	1.77
10	1	3.71	21	1	1.67
11	9	3.52	22	1	1.57

* Diffuse line.

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REFERENCES

BEINTEMA, J., On the composition and the crystallography of autunite and the meta-autunites: *Rec. Trav. Chim. Pays-Bas*, **57**, 155–175 (1938).

SCHOEP, A., Splijtingen, Corrosie-figuren en monokliene Symmetrie van Saléeiet; epitaxie op Metatorberniet: *Meded. Kl. Wetens. Kon Vlaamsche Acad. Wetens Lett.*, 65–70, Gent (1939).

THOREAU, J., AND VAES, J. F., La saléeite, nouveau minéral uranifére: *Bull. soc. belge géol.*, **42**, 96–100 (1932).