CHERNIKOVITE

a new mineral name for $(H_3O)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$ superseding "hydrogen autunite"

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ABSTRACT

Chernikovite, $(H_3O)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$, is a new name proposed for a mineral originally found in the USSR. A second occurrence from Brazil and a third from the USSR are also recorded.

The type material from the USSR forms thin, transparent, mica-like plates, elongated along [010], with a perfect (001) and an imperfect (100) cleavage. The color is pale yellow, the luster vitreous and the ultraviolet fluorescence intense yellow-green. Optically the mineral is uniaxial (−) with $\epsilon = 1.569$ and $\omega = 1.583$. The mineral is tetragonal with unit cell parameters a = 7.030(6) and c = 9.034(8)Å; the strongest X-ray lines are [d in Å (I)(hkl)] 5.51(90)(101), 4.99(100)(110), 3.82(80)(102), 3.54(100)(200) and 3.26(100)(201).

The Brazilian material occurs at Perus, São Paulo, as inclusions in autunite and meta-autunite, which line fractures in granites and granitic pegmatites. It is optically lemon-green and slightly pleochroic, uniaxial (−) or slightly biaxial, $\epsilon = 1.570$ and $\omega = 1.580$. The unit cell parameters are a = 7.016(3) and c = 9.055(4)Å; the strongest X-ray lines are 9.00(100)(001), 3.78(90)(102), 3.50(70)(200), 3.27(80)(201) and 2.77(70)(103, 202).

Synthetic chernikovite consists of microscopic square and octagonal plates, uniaxial (−), with $\epsilon = 1.568(1)$ and $\omega = 1.579(1)$. Chemical analysis gives UO_3 = 65.08, P_2O_5 = 16.03, H_2O = 19.33, total 100.44 weight %. Cell parameters are a = 7.020(5) and c = 9.043(5)Å; the strongest X-ray lines are 9.032(100)(001), 3.799(90)(102), 3.511(70)(200), 3.270(80)(201) and 2.765(70)(103, 202). The calculated density is 3.264 g/cm³ for the synthetic material and for the Brazilian chernikovite, and 3.258 g/cm³ for the Soviet chernikovite. Chernikovite is probably isostructural with meta-ankoleite, uramphite and abernathyite. The original name for chernikovite, "hydrogen autunite," is misleading and is now discarded.

INTRODUCTION

The name "hydrogen autunite" was proposed for a synthetic product studied by various authors, e.g., Lienau (1898), Frondel (1950) and Ross (1955). A naturally occurring substance from the USSR was identified with this material by Chernikov (1958). A second occurrence from Brazil was described by Camargo (1971), and a third occurrence from the USSR was recorded by Kashirtseva and Valueva (1979). The I.M.A. Commission on New Minerals and Mineral Names never approved "hydrogen autunite," and the name is not reported in the *Glossary of Mineral Species* (Fleischer, 1987). Since the name "hydrogen autunite" is misleading, it is here proposed to change the name of the mineral to chernikovite as a tribute to A. A. Chernikov. Both the mineral and its new name were approved by the I.M.A. Commission on New Minerals and Mineral Names. This note presents a compilation of pertinent mineralogical data on chernikovite.

OCCURRENCE AND PARAGENESIS

Neither Chernikov (1958) nor Kashirtseva and Valueva (1979) gave any indication of the exact location of the Soviet occurrences. The mineral studied by Camargo (1971) was found at a quarry in the Perus district, 25 km north of the city of São Paulo, Brazil, as inclusions in autunite and meta-autunite. Other secondary uranium minerals associated with Brazilian chernikovite are uranophane, uranophane-beta, phosphuranylite, torbernite, metatorbernite, haiweeite, and uranian opal. These minerals occur on fractures and joint surfaces of tourmaline-bearing granites and granitic pegmatites. The Soviet chernikovite studied by Kashirtseva and Valueva (1979) is associated with autunite, meta-autunite, and sodium autunite, and appears on fissures within quartz syenite and around fossil wood contained in conglomerates.

HABIT AND PHYSICAL PROPERTIES

The Soviet chernikovite (Chernikov, 1958) forms thin, transparent, mica-like plates, elongated along [010], with a perfect (001) and an imperfect (100) cleavage. Its color is pale yellow, the luster is vitreous, and there is an intense yellow-green ultraviolet fluorescence. The Brazilian chernikovite (Camargo, 1971) occurs mainly as oriented and neatly zoned inclusions in autunite and meta-autunite (Fig. 1a). The inclusions commonly display rod-like forms in parallel orientation with the host and on the whole exhibit a hieroglyph-like aspect (Fig. 1b). There are also small plates with irregular or geometrical contours, whose size does not exceed 10 μm (Fig. 1c). Inclusions of chernikovite are observed growing parallel to autunite cleavages (Fig. 1d). The synthetic chernikovite described by Ross (1955) consists of microscopic square and octagonal plates. The calculated density for the ideal formula is 3.264 g/cm³ for the synthetic material, 3.258 g/cm³ for the Soviet chernikovite, and 3.264 g/cm³ for the Brazilian chernikovite.

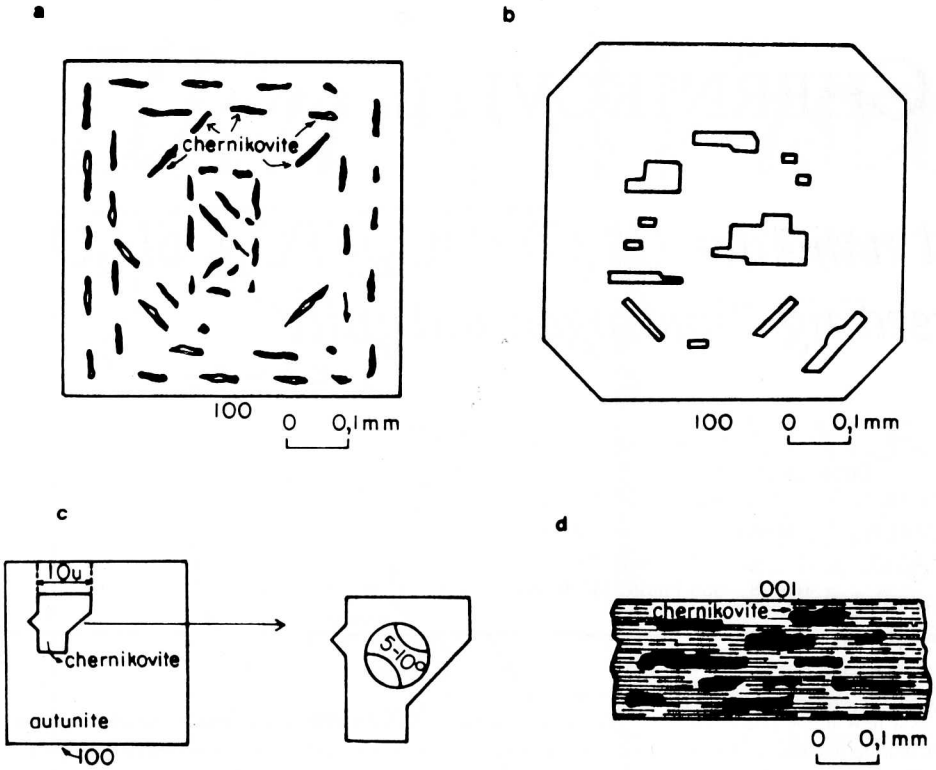

Figure 1. **(a) Oriented inclusions of chernikovite in autunite. Note the zoned pattern of the inclusions. (b) Hieroglyph-like inclusions of chernikovite in autunite. (c) Idiomorphic plate of chernikovite in autunite. (d) Inclusions of chernikovite oriented parallel to the (001) autunite cleavage (Camargo, 1971).**

OPTICAL PROPERTIES

Chernikovite is uniaxial negative. The Brazilian material is lemon-green and slightly pleochroic. The largest plates may be anomalously biaxial, with $2V^{-}$ 5–10° (Camargo, 1971). Table 1 presents refractive indices recorded for natural and synthetic chernikovite. Brazilian chernikovite can be easily recognized as an inclusion by its refractive indices, which are lower than those of the autunite and meta-autunite hosts (Camargo, 1971).

CHEMICAL DATA

Chemical data for the synthetic material (Ross, 1955) are listed in Table 2 and are consistent with the ideal formula $(H_3O)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$. Of the total hydration water 9.28 weight % is lost at 110°C (Ross, 1955). Spectrographic analyses of the Soviet samples (Chernikov, 1958) yield abundant U and P, and traces of other elements which are considered to be impurities. Infrared spectrographic data for Brazilian autunite with meta-autunite and chernikovite inclusions are available, and these indicate the presence of phosphate and uranyl ions and water. No impurity peaks were observed (Camargo, 1971).

CRYSTALLOGRAPHY

The X-ray powder diffraction data of chernikovite (Table 3) can be indexed on a tetragonal unit cell having the probable space-group *P4/nmm*. The cell content is $(H_3O)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$ with $Z = 1$. However, the cell parameters, refined by least-squares, given in Table 4, may actually represent a pseudo-cell. By analogy with the meta-autunite group minerals studied by Ross and Evans (1964), the *c* dimension may be doubled and the space group of the pseudo-cell would then be *P4/ncc*. On the other hand, if the cell relationships in chernikovite are the same as those in meta-autunite (I) (Ross, 1963), the true cell would be generated by rotating the pseudo-cell 45° about the *c*-axis and the space group would thus be $P4_222$.

Powder diffraction patterns of chernikovite exhibit, on account of its easy (001) cleavage, a very strong (001) reflection, located between the (002) peak of autunite and the (001) peak of meta-autunite; when the three minerals occur together, identification of the phases is very easy (Camargo, 1971). The 9 Å peak of autunite often mentioned in the literature may actually correspond to admixed chernikovite, as clearly shown by Camargo (1971) in the case of Brazilian material.

Calculations using the Gladstone-Dale relationship for the ideal formula, the calculated density and the recorded refractive indices, using constants reported by Mandarino (1976), yield $K_P = 0.176$ for the synthetic material, $K_P = 0.177$ for the Soviet and Brazilian chernikovite, and $K_C = 0.168$ for the three materials. Hence $1-(K_P/K_C)$ is -0.0476 for the synthetic material, and -0.0536 for the Soviet and Brazilian chernikovite indicating good compatibility in all cases (Mandarino, 1979).

NOMENCLATURE AND RELATIONSHIP TO OTHER SPECIES

The name chernikovite honors Dr. A. A. Chernikov, of the Institute of Mineralogy, Geochemistry and Crystallochemistry of Rare Elements, Moscow, USSR, who first described the naturally occurring mineral (Chernikov, 1958). The name "hydrogen autunite" should be discarded for several reasons:

(1) The mineral contains $(H_3O)^+$ ions and not simply H^+.

(2) Its degree of hydration is the same as that observed for minerals of the meta-autunite group, whereas the name autunite is reserved for minerals with 10 to 12 molecules of H_2O. The name "hydrogen autunite" therefore violates this usage.

(3) The name "hydrogen autunite" has also been used for other natural (Belova, 1975) and artificial compounds (Harris and Scott, 1949; Weiss *et al.*, 1957; Moroz *et al.*, 1973). These incompletely studied substances have different properties including refractive indices, densities and *c* dimensions of their unit cells. Such compounds may actually be polymorphs of chernikovite (Moroz *et al.*, 1973); alternatively, they may represent compounds with different degrees of hydration (as suggested by Chernikov, 1958) or phases where the

Table 1. **Refractive indices for chernikovite.**

	1	2	3
X = ϵ	1.568(1)	1.569	1.570
Z = ω	1.579(1)	1.583	1.580

1. Synthetic (Ross, 1955).
2. USSR (Chernikov, 1958).
3. Perus, São Paulo, Brazil (Camargo, 1971).

Table 2. **Chemical data for chernikovite (wt. %).**

	1	2
UO_3	65.29	65.08
P_2O_5	16.20	16.03
H_2O	18.51	19.33
Total	100.00	100.44

1. $(H_3O)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O$.
2. Synthetic (Ross, 1955).

two $(H_3O)^+$ ions are substituted by one $(UO_2)^{+2}$, as may be the case with trögerite and "hydrogen uranospinite" (Shchipanova *et al.*, 1971). A specimen of the type material (studied by Chernikov, 1958) is deposited in the A. E. Fersman Mineralogical Museum of the Academy of Science of the USSR in Moscow (Chernikov, personal communication).

Chernikovite has an X-ray powder diffraction pattern similar to those of the minerals meta-ankoleite $[K_2(UO_2)_2(PO_4)_2 \cdot 6H_2O]$, uramphite $[(NH_4)_2(UO_2)_2(PO_4)_2 \cdot 6H_2O]$, and abernathyite $[K_2(UO_2)_2(AsO_4)_2 \cdot 6H_2O]$ and to the synthetic products $(NH_4)_2(UO_2)_2(AsO_4)_2 \cdot 6H_2O$ and $K(H_3O)(UO_2)_2(AsO_4)_2 \cdot 6H_2O$ studied by Mrose (1953) and Ross and Evans (1964). These compounds may be isostructural with chernikovite. An unnamed mineral, referred to as the phosphorus analog of trögerite and to which the formula $(UO_2)_3(PO_4)_2 \cdot 8H_2O$ has been ascribed, was reported by Belova *et al.* (1963). The powder diffraction pattern, represented on card 26-887 in the JCPDS file, is apparently from a mixture of two phases, one of which had peaks indexed, while the other shows peaks which could not be indexed. The material whose peaks have been indexed is possibly the natural analog of the synthetic compound $(UO_2)_3(PO_4)_2 \cdot 8H_2O$, cited by Belova *et al.* (1963), and the other probably corresponds to chernikovite.

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Table 4. **Unit-cell parameters for chernikovite.**

	1	2	3
a(Å)	7.020(5)	7.030(6)	7.016(3)
c(Å)	9.043(5)	9.034(8)	9.055(4)
V(Å^3)	445.6	446.5	445.7
c:a	1.288	1.285	1.291

1. Synthetic (Ross, 1955; JCPDS 8-296).
2. USSR (calculated from the data of Chernikov, 1958).
3. Perus, São Paulo, Brazil (calculated from the data of Camargo, 1971).

Table 3. **X-ray diffraction data for chernikovite.**

1		2		3		
d(Å)	I/I_o	d(Å)	I/I_o	d(Å)	I/I_o	hkl*
9.032	100	8.89	40	9.00	100	001
5.556	50	5.51	90	5.59	60	101
4.971	40	4.99	100	4.96	60	110
4.542	5	—	—	4.51	5	002
4.360	30	4.29	50	4.34	50	111
3.799	90	3.82	80	3.78	90	102
3.511	70	3.54	100	3.50	70	200
3.270	80	3.26	100	3.27	80	201
2.964	60	2.96	60	2.96	50	211
2.765	70	2.77	40	2.77	70	103, 202
2.576	30	2.57	40	2.58	10	113, 212
2.488	30	2.49	50	2.49	30	220
2.397	40	2.40	60	2.40	30	221
2.267	20	2.27	60	2.26	30	004, 301
2.216	30	—	—	2.22	30	310
2.163	50	2.16	70	2.17	30	104, 213, 222, 311
2.075	40	2.09	70	2.08	30	302
—	—	2.01	50	—	—	312
1.902	20	1.906	40	1.900	20	204, 321
1.844	30	1.850	40	1.847	10	303
1.789	30	1.795	50	1.786	20	313, 322
1.755	20	1.749	20	1.753	20	105, 400
1.722	20	1.727	20	1.722	20	401
1.697	30	1.680	20	1.699	20	115
1.633	30	1.642	30	1.630	20	323, 402
1.61–1.57	30	1.618	30	1.590	30	314, etc.
		1.570	50			
1.546	10	1.550	20	1.543	20	421
1.477	10	1.473	10	1.478	5	106, 324, 413, 422
1.439	10	—	—	1.441	10	116
1.401	20	1.401	10	1.401	15	315
1.383	10	1.381	40	1.385	10	206, 404, 431, 501
1.359	10	—	—	1.360	10	216, 414, 511
1.338	5	1.335	10	1.339	10	334, 432, 502
1.288	5	—	—	1.288	5	226, 424, 521
1.270	10	1.271	10	1.271	10	107, 306, 433, 503
1.249	20	1.245	10	1.248	10	117, 316, 513, 522
1.221	5	1.221	20	1.223	5	335
—	—	1.201	10	—	—	530
1.194	30	1.192	20	1.193	20	217, 326, 434, 442, 504, 523, 531
		1.172	50			
		1.109	20			
		1.097	20			
		1.064	20			
		1.021	10			
		1.006	10			

*For the *P4/nmm* cell.
1. Synthetic (Ross, 1955; JCPDS 8-296).
2. USSR (Chernikov, 1958).
3. Perus, São Paulo, Brazil (Camargo, 1971).

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