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Sundiusite, a new lead sulfate oxychloride from Långban, Sweden

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Abstract

Sundiusite, $Pb_{10}(SO_4)Cl_2O_8$, is a new mineral from Långban, Sweden. It is monoclinic, *C*2, *Cm*, or *C*2/*m*, with $a = 24.67(1)$, $b = 3.781(1)$, $c = 11.881(5)$Å, $\beta = 100.07(4)°$, and $Z = 2$. The strongest lines in the X-ray powder pattern are (Å,*I*, *hkl*) 2.981 *10* 510; 2.737 *8* $\bar{1}13$; 3.101 *6* 602,$\bar{6}03$; 3.044 *6* 800,403; 6.10 *3* 400; 3.744 *3* 110. Sundiusite occurs as plumose aggregates of white to colorless crystals with an adamantine luster. The Mohs hardness is about 3, and there is a perfect {100} cleavage. Optically, it appears to be biaxial (+) with all indices greater than 2.10; lath-shaped fragments are length-slow. The observed and calculated densities are 7.0 and 7.20 g/cm^3, respectively. The mineral does not fluoresce in ultraviolet radiation.

The composition, as determined by electron microprobe, is PbO 93.1, FeO 0.5, SO_3 3.5, Cl 3.0, less O ≡ Cl 0.7, total 99.4 weight percent, which yields the ideal formula $Pb_{10}(SO_4)Cl_2O_8$. The composition and cell geometry suggest a structural relationship to the nadorite group. Sundiusite is known only from Långban and is identical with Flink unknown #284. The name is for the late Nils Sundius.

Introduction

This new mineral species was found several years ago on a specimen in the collections of the Smithsonian Institution. The new species was later identified as one of those minerals of unknown identity noted from Långban by the mineralogist and collector, Gustav Flink (1849–1931). Flink published many lists of Långban minerals which he considered worthy of further investigation. The references to these lists are given in a report on the status of the "Flink unknowns" by Moore *et al.* (1971).

We take pleasure in naming this new mineral sundiusite after the late Swedish mineralogist Nils Sundius (1886–1976) in recognition of his numerous contributions to the study of Långban mineralogy including his classic study of the manganiferous pyroxenoids (Sundius, 1931). The pronounciation of the name is sūn-dē-ūs-ite. The name sundiusite has been previously used to denote the hypothetical sodic–calcic amphibole, $NaCaNaMg_3Al_2Si_6O_{22}(OH)_2$ (Phillips and Layton, 1964). However, this name was not recognized by the Subcommittee on Amphiboles, IMA, in its recent systemization of amphibole nomenclature (Leake, 1968) and indeed "sundiusite" was not even included in its list of amphibole names which should be abandoned. Since this compound is unknown as a natural mineral and since the name has not gained popular acceptance, we feel justified in using sundiusite for the new species from Långban. The mineral and name have been approved by the IMA Commission on New Minerals and Mineral Names. The type specimen is preserved in the Smithsonian Institution collection under catalog #NMNH 134984.

Physical and optical properties

Sundiusite occurs exclusively as plumose aggregates of white to colorless crystals up to 8 mm in length. The aggregates are composed of overlapping plates, which are slightly offset from one another in a diverging manner. The streak is white and the luster adamantine. There is one perfect cleavage parallel to

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{100}. The mineral is quite brittle, breaking easily into lath-shaped fragments, whose longest dimension is parallel to the *b* crystallographic axis. A possible second cleavage may exist parallel to {001} but is very poorly developed. The Mohs hardness is approximately 3. The density, determined using a Berman balance and temperature correction, is 7.0±0.2 g/cm^3, in good agreement with the calculated value of 7.20 g/cm^3. Optically, sundiusite appears to be biaxial (+) with refractive indices all >2.1. The maximum birefringence, determined with a tilting compensator, is 0.070. Cleavage laths are length-slow. There is no response to ultraviolet radiation. Sundiusite, along with blixite, occurs on fracture surfaces of an ore consisting of braunite, hausmannite, calcite, and manganoan biotite. It is the last mineral of this assemblage to form.

Sundiusite is similar in appearance to several other minerals, the most notable of which are hydrocerussite and mendipite. The resemblance to mendipite, $Pb_3O_2Cl_2$, from the Mendip Hills, England is particularly striking. Although neither mineral fluoresces under ultraviolet radiation, the calcite associated with each has a similar fluorescence, which accentuates the resemblance between mendipite and sundiusite. This has led to some confusion, a matter which will be discussed in a subsequent section.

Chemistry

Sundiusite was chemically analyzed with an ARL-SEMQ electron microprobe, at an operating voltage of 15 kV and a beam current of 0.15 μA, determined using a beam current monitor. The standards used were PbO for lead, celestine for sulfur, hornblende for iron, and halite for chlorine. A wavelength-dispersive scan indicated the absence of any other elements with atomic number greater than nine. The data were corrected using a modified version of the *MAGIC-4* program. The resulting analysis is presented in Table 1. Calculation of the unit-cell contents using the observed density yields $Pb_{19.3}Fe_{0.3}S_{2.0}Cl_{3.9}O_{23.6}$ in good agreement with the theoretical composition $Pb_{10}(SO_4)Cl_2O_8$ with two formula weights per cell. Sundiusite is chemically homogeneous and is very slowly soluble in 1:1 cold HCl or HNO_3.

Crystallography

Sundiusite was studied by Weissenberg, precession, and oscillating crystal methods. The mineral is monoclinic, *C*2, *Cm*, or *C*2/*m*, with $a = 24.67$ *esd* 0.01, $b = 3.781$ *esd* 0.001, and $c = 11.881$ *esd* 0.005Å, $\beta = 100.07$ *esd* 0.04°, and $V = 1091.1$ *esd* 0.8Å^3.

Table 1. Electron microprobe analysis of sundiusite

	SUNDIUSITE	Theoretical $Pb_{10}(SO_4)Cl_2O_8$
PbO	93.1	94.30
FeO	0.5	
SO_3	3.5	3.38
Cl	3.0	3.00
Total	100.1	100.68
Less O = Cl	0.7	0.68
Total	99.4	100.00

Accuracy of data: ±3% of the amount present. Quantities given are in weight percent.

There is also a prominent subcell with A = 24.67, B = 3.781, C = $c/3$ = 3.960Å, and $\beta = 100.07°$. Cell parameters were refined by least-squares from Debye-Scherrer data utilizing NBS silicon (a = 5.4309Å) as an internal standard. The X-ray powder diffraction data are given in Table 2.

Table 2. X-ray powder diffraction data for sundiusite

I_{obs}	d_{obs}	d_{cal}	hkl	I_{obs}	d_{obs}	d_{cal}	hkl
<1	12.0	12.1	200			2.042	$\bar{9}13$
1	9.29	9.27	$\bar{2}01$	2b	2.033	2.024	12·0·0
1	7.79	7.77	201			2.022	$\bar{7}13$
3	6.10	6.07	400	2	1.980	1.980	$\bar{2}06$
<<1	5.78	5.82	$\bar{4}01$	2	1.890	1.891	020,$\bar{6}06$
		5.67	$\bar{2}02$	2	1.826	1.825	$\bar{11}$·1·3
<1	4.03	4.05	600	2	1.807	1.807	913
2	3.914	3.917	$\bar{2}03$			1.805	420
		3.899	003			1.752	515
3	3.744	3.736	110	<1	1.747	1.751	$\bar{3}16$
		3.578	$\bar{4}03$			1.748	$\bar{1}16$
2b	3.553	3.537	203			1.710	116
		3.532	111	1	1.704	1.701	023
2	3.428	3.426	$\bar{3}10$			1.699	$\bar{14}$·0·3
<1	3.349	3.356	$\bar{3}11$			1.680	12·0·3
				2	1.676	1.675	$\bar{13}$·1·0
6	3.101	3.091	$\bar{6}03$			1.672	$\bar{4}23$
		3.086	602			1.671	007
6	3.044	3.048	403				
		3.036	800	1	1.657	1.657	$\bar{7}16$
10	2.981	2.984	510	1	1.639	1.643	316
						1.635	$\bar{13}$·1·3
<<1	2.892	2.911	$\bar{8}02$	2	1.608	1.607	423
8	2.737	2.735	$\bar{1}13$			1.605	820
<1	2.628	2.629	$\bar{8}03$				
<1	2.559	2.567	$\bar{7}11$	<<1	1.551	1.546	$\bar{12}$·0·6
		2.556	710			1.492	10·2·0
				1	1.490	1.491	14·0·3
						1.488	15·1·0
<<1	2.491	2.503	$\bar{5}13$				
		2.484	313	1	1.368		
2	2.428	2.433	711				
		2.429	10·0·0	<<1	1.353		
1	2.274	2.277	$\bar{7}13$	<<1	1.267		
		2.273	114	<1	1.244		
<<1	2.186	2.195	604	<1	1.220		
				1	1.201		

114.6 mm Debye-Scherrer camera, CuKα radiation, NBS silicon internal standard, b = broad line

The subcell dimensions of sundiusite suggest a relationship between the new mineral and members of the nadorite group. As shown in Table 3, the lattice parameters of orthorhombic nadorite, perite, and blixite are related to those of synthetic tetragonal nadorite (SN) such that $a \simeq c \simeq a_{SN}\sqrt{2}$ and $b \simeq c_{SN}$ or $2c_{SN}$. In other words the basic geometrical unit common to all of them is either tetragonal or pseudotetragonal with parameters A ≃ 4 and C ≃ 12Å. This corresponds to the sundiusite subcell with its A parameter halved. It may also be noted that nadorite and its congeners possess a single perfect cleavage perpendicular to their 12 (or 25) Å translation, reflecting the layered character of their crystal structures (Giuseppetti and Tadini, 1973). Sundiusite also possesses a single perfect cleavage nearly perpendicular to its 25 Å translation. From the foregoing similarities we infer that sundiusite is a lead oxychloride with a layered structure related to those of the nadorite group.

If sundiusite is indeed related to nadorite as proposed, the presence of the sulfate ion is somewhat incongruous, as the nadorite structure contains no tetrahedral anions. An explanation may be that the nadorite minerals are a part of a larger family of bismuth, lead, and antimony oxyhalides (*Structure Reports,* 1947–1948, p. 305–320), some of which contain complex anions, *e.g.* CO_3^{2-} and MoO_4^{2-}, which play the same structural role as the halide ions. This may also be the role of SO_4^{2-} in the sundiusite structure.

Identity of sundiusite and Flink unknown #284

The original label that accompanied the specimen gives very little information; it simply states "#284, 285, Långban." In one of his lists of new or incompletely described minerals from Långban (Flink, 1924), the number 284 is assigned to a lath-like, snow white, highly lustrous mineral from the Amerika stope. This description is in good agreement with the appearance of sundiusite, and it would seem that the two minerals are identical (Flink #285 is blixite). However, we note that Moore *et al.* (1971) attribute #284 to mendipite on the basis of density and single-crystal X-ray photographs. Subsequent to our characterization of sundiusite, a number of specimens of Flink #284 were located in the Flink collection at Harvard University. Both sundiusite and mendipite were identified by powder X-ray photography on these specimens, but the two minerals do not occur together on any one specimen. Hence, Flink number 284 was probably assigned to two separate minerals, which would have been difficult for Flink to distinguish by sight or density measurements, the densities of sundiusite and mendipite being 7.20 and 7.22 g/cm^3, respectively. Mendipite has also been reported from Långban by Goñi and Guillemin (1953).

Table 3. Crystal chemical data for minerals of the nadorite group

	Formula	Space Group	Unit Cell (A)		
			a	*b*	*c*
Nadorite[a]	$PbSbO_2Cl$	*Cmcm*	5.60	12.24	5.45
Perite[b]	$PbBiO_2Cl$	*Cmcm*	5.63	12.42	5.58
Blixite[c]	$Pb_{16}(O,OH)_{16-x}Cl_8$	Orthorhombic	5.83	25.47	5.69
Nadorite[d] (synthetic)	$PbSbO_2Cl$	*I4/mmm*	a = 3.90, c = 12.29		

[a]Giuseppetti and Tadini (1973), [b]Gillberg (1961), [c]Gabrielson et al. (1960), [d]Sillén and Melander (1941).

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References

Flink, G. (1924) Förteckning på Stockholms Högskolas samling av nya eller ofullständigt beskrivna mineral från Långban (fortsättning). *Geol. Fören. Förh., 46,* 704–709.

Gabrielson, O., A. Parwel and F. E. Wickman (1960) Blixite, a new lead oxychloride from Långban. *Ark. Mineral. Geol., 2,* 411–415.

Gillberg, M. (1961) Perite, a new oxyhalide mineral from Långban, Sweden. *Ark. Mineral. Geol., 2,* 565–570.

Giuseppetti, G. and C. Tadini (1973) Riesame della struttura cristallina della nadorite: $PbSbO_2Cl$. *Periodico Mineral. (Roma), 42,* 335–345.

Goñi, J. and C. Guillemin (1953) La mendipite de Långban, Vermland, Suède. *Bull. Soc. fr. Minéral. Cristallogr., 76,* 216–218.

Leake, B. E. (1978) Nomenclature of amphiboles. *Am. Mineral., 63,* 1023–1052.

Moore, P. B., F. E. Wickman, R. Blix, O. Gabrielson, M. E. Gilberg and A. Parwel (1971) The Flink collection of unknown Långban minerals: a progress report. *Geol. Fören. Förh., 93,* 289–301.

Phillips, R. and W. Layton (1964) The calciferous and alkali amphiboles. *Mineral. Mag., 33,* 1097–1109.

Sillén, L. G. and L. Melander (1941) X-ray studies on the oxyhalide minerals nadorite (ochrolite) $PbSbO_2Cl$ and ekdemite. *Z. Kristallogr., 103,* 420–430.

Structure Reports (1947–1948) Vol. 11. Oosthoek, Utrecht.

Sundius, N. (1931) On the triclinic manganiferous pyroxenes. *Am. Mineral., 16,* 411–429 and 488–518.

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