Canadian Mineralogist
Vol. 29, pp. 359-362 (1991)

SILINAITE, A NEW SODIUM LITHIUM SILICATE HYDRATE MINERAL FROM MONT SAINT-HILAIRE, QUEBEC

GEORGE Y. CHAO

Ottawa-Carleton Geoscience Centre, Department of Earth Sciences, Carleton University, Ottawa, Ontario K1S 5B6

JOEL D. GRICE AND ROBERT A. GAULT

Mineral Sciences Section, Earth Sciences Division, Canadian Museum of Nature, Ottawa, Ontario K1P 6P4

ABSTRACT

Silinaite, ideally $NaLiSi_2O_5 \cdot 2H_2O$, is a new mineral species from the Poudrette quarry, Mont Saint-Hilaire, Quebec. It occurs as clear tabular crystals up to 2 mm, fibrous clusters, poorly formed prismatic crystals, and chalky to earthy or powdery patches in sodalite syenite xenoliths in the nepheline syenite. It is associated with many rare species such as erdite, kogarkoite, tugtupite, vitusite-(Ce), makatite, thalcusite, chkalovite, sazhinite-(Ce), sidorenkite, revdite, rasvumite, natrophosphate and many unidentified minerals. The mineral is brittle, colorless to white with a white streak, opaque to translucent or transparent with vitreous to earthy luster. Cleavages {001} perfect, {010} good and {110} distinct; fracture conchoidal; Mohs hardness 4.5; *D*(meas.) 2.24(1), *D*(calc.) 2.22 and 2.23 g/cm^3; non-fluorescent in ultraviolet light. Optically biaxial positive, α 1.515(1), β 1.516(1), γ 1.518(1), $2V$ (meas.) 64(1)°, $2V$(calc.) 71° (λ 589 nm). Orientation: $X = b$, $Y \wedge c = 16°$ in the acute β angle. Nonpleochroic; strong $r > v$, inclined. Silinaite is monoclinic, $A2/n$, a 5.061(1), b 8.334(2), c 14.383(3) Å, β 96.67(2)°, $Z = 4$. The strongest eight X-ray Gandolfi diffraction lines [d in Å (I)(hkl)] are: 7.14(100)(011,002), 4.24(80)($\bar{1}$11), 4.14(100)(013), 4.02(80)(111), 2.847(100)(122), 2.698(50)(015), 1.610(40)(311, $\bar{1}$37, 240), 1.557(40)($\bar{3}$22). The ideal chemical formula is derived from a crystal-structure analysis. Electron-microprobe analyses gave: SiO_2 58.54, 58.72; Al_2O_3 0.01, 0.00; CaO 0.14, 0.42; Na_2O 14.96, 13.66; Li_2O(calc.) 7.28, 7.25; H_2O(calc.) 17.56, 17.47; sums 98.49, 97.52 wt.%, corresponding to $(Na_{0.99}Ca_{0.01})LiSi_{2.00}O_5 \cdot 2H_2O$ and $(Na_{0.91}Ca_{0.02})LiSi_{2.02}O_5 \cdot 2H_2O$. The name is derived from the composition.

Keywords: silinaite, sodium lithium silicate hydrate, new mineral species, Mont Saint-Hilaire, Quebec, occurrence, properties, X-ray data, chemical composition.

SOMMAIRE

La silinaïte, de composition idéale $NaLiSi_2O_5 \cdot 2H_2O$, est une nouvelle espèce minérale découverte dans la carrière Poudrette, au mont Saint-Hilaire, Québec. Elle se présente en tablettes jusqu'à 2 mm en longueur, en amas de fibres, en cristaux prismatiques difformes, et en amas crayeux ou pulvérulents dans des enclaves de syénite à sodalite dans la syénite néphélinique. Lui sont associés plusieurs espèces rares, dont erdite, kogarkoïte, tugtupite, vitusite-(Ce), makatite, thalcusite, chkalovite, sazhinite-(Ce), sidorenkite, revdite, rasvumite et natrophosphate, ainsi que plusieurs espèces non identifiées. La silinaïte est cassante, incolore à blanc, à rayure blanc, opaque à translucide ou transparente, avec un éclat vitreux ou terreux. Parmi les clivages, {001} est parfait, {010} est bon, et {110}, distinct. La fracture est conchoïdale. La dureté de Mohs est 4½; la densité est 2.24(1) (mesurée), 2.22 et 2.23 (calculée). Elle est non fluorescente en lumière ultra-violette. Optiquement biaxe positive, α 1.515(1), β 1.516(1), γ 1.518(1), $2V$ 64 (1)° (mesuré), 71° (calculé) (λ 589 nm). Orientation: $X = b$, $Y \wedge c = 16°$ dans l'angle β aigu. Non pléochroïque, forte dispersion $r > v$, inclinée. La silinaïte est monoclinique, $A2/n$, a 5.061(1), b 8.334(2), c 14.383(3) Å, β 96.67(2)°, $Z = 4$. Les huit raies les plus intenses du cliché de diffraction (méthode de Gandolfi) [d en Å (I)(hkl)] sont: 7.14(100)(011,002), 4.24(80)($\bar{1}$11), 4.14(100)(013), 4.02(80)(111), 2.847(100)(122), 2.698(50)(015), 1.610(40)(311,$\bar{1}$37, 240) et 1.557(40)($\bar{3}$22). La formule chimique idéale est dérivée d'une ébauche de la structure cristalline. Les analyses à la microsonde électronique ont donné (en %, poids): SiO_2 58.54, 58.72; Al_2O_3 0.01, 0.00; CaO 0.14, 0.42; Na_2O 14.96, 13.66; Li_2O (calculé) 7.28, 7.25; H_2O (calculé) 17.56, 17.47, pour un total de 98.49, 97.52%, respectivement, ce qui correspond à $(Na_{0.99}Ca_{0.01})LiSi_{2.00}O_5 \cdot 2H_2O$ et $(Na_{0.91}Ca_{0.02})LiSi_{2.02}O_5 \cdot 2H_2O$. Le nom rappelle la composition.

(Traduit par la Rédaction)

Mots-clés: silinaïte, silicate hydraté de sodium et de lithium, nouvelle espèce minérale, propriétés, données de diffraction, composition chimique, mont Saint-Hilaire, Québec.

INTRODUCTION

The unidentified mineral UK81 (Chao *et al.* 1990) from the Poudrette quarry, Mont Saint-Hilaire, Quebec, has been shown by electron-microprobe analyses, optical and physical properties and crystal-structure analysis to be a new species. It is named *silinaite*, after its composition (Si-Li-Na-ite). The mineral and mineral name have been approved by the Commission on New Minerals and Mineral Names, IMA. The type specimens are deposited at the Canadian Museum of Nature (CMN #56467 and #56468), and the Royal Ontario Museum (M44516 and M44517).

TABLE 1. X-RAY POWDER-DIFFRACTION DATA FOR SILINAITE

hkl	I_{calc}	d_{calc}	I_{est}	d_{meas}
011	19	7.1986	100	7.14
002	38	7.1428		
$\bar{1}11$	48	4.2395	80	4.24
013	100	4.1346	100	4.14
111	37	4.0126	80	4.02
022	9	3.5993	20	3.599
004	9	3.5714	20	3.574
$\bar{1}13$	4	3.3640	10	3.366
120	18	3.2081	20	3.208
113	26	3.0460	20	3.046
$\bar{1}22$	87	3.0111	20	3.014
122	50	2.8486	100	2.847
015	32	2.7027	50	2.698
200	16	2.5134	20	2.514
$\bar{1}24$	8	2.4797	20	2.484
$\bar{2}02$	9	2.4621	20	2.464
$\bar{2}11$	11	2.4173	20	2.417
131	5	2.3750	20	2.381
211	3	2.3308	5	2.332
124	10	2.3032	20	2.301
$\bar{2}13$	2	2.2508	5	2.255
$\bar{1}33$	8	2.2165	5	2.214
$\bar{2}04$	9	2.1779	10	2.180
220	0	2.1522	5	2.154
133	3	2.1178	5	2.118
040	10	2.0835	10	2.086
213	11	2.0576	10	2.051
042	5	2.0001	5	2.004
035	3	1.9917		
$\bar{1}26$	1	1.9836	10	1.980
017	10	1.9822		
$\bar{1}17$	9	1.9194	5	1.918
$\bar{1}35$	5	1.9053		
$\bar{1}42$	10	1.8796	10	1.873
$\bar{2}31$	16	1.8689		
126	11	1.8475	20	1.846
135	2	1.8024	5	1.804
044	3	1.7996		
008	2	1.7857	5	1.785
215	5	1.7473	10	1.746
311	12	1.6113	40	1.610
$\bar{1}37$	19	1.6083		
240	3	1.6040		
$\bar{1}51$	1	1.5788	5	1.575
053	4	1.5732		
$\bar{3}22$	16	1.5542	40	1.557
226	2	1.5230	10	1.523
137	2	1.5216		
$\bar{2}44$	9	1.5055	5	1.509
0010	3	1.4286	10	1.428
331	7	1.4137	15	1.415
$\bar{3}33$	2	1.4131		
$\bar{1}55$	2	1.4060		
$\bar{2}19$	4	1.3984		
$\bar{2}51$	6	1.3912	10	1.392
060	1	1.3890		
208	7	1.3819	10	1.380
039	3	1.3782	10	
$\bar{1}39$	3	1.3647	10	1.366
062	3	1.3635		
315	2	1.3588		
$\bar{1}210$	9	1.3425	10	1.342
333	1	1.3375		
$\bar{3}35$	1	1.3366		
228	2	1.3116		
253	1	1.3111	20	1.311
162	4	1.3086		

114.6 mm Gandolfi camera, CuKα radiation (λ 1.5418Å), I_{est} visually estimated, I_{calc} from crystal-structure analysis (Grice 1991).

Occurrence

Silinaite, ideally $NaLiSi_2O_5 \cdot 2H_2O$, occurs in sodalite syenite xenoliths in nepheline syenite at the Poudrette quarry, Mont Saint-Hilaire, Quebec. The xenolith that contained the cotype specimens is estimated to be 1–2 m in diameter and is mainly (over 80% by volume) composed of coarse-grained sodalite with minor microcline, natrolite and analcime; it is locally enriched in ussingite. At least 72 minerals have been found in this single xenolith, including unidentified minerals UK38, UK53, UK53A, UK63, UK74, UK82, UK83 (Chao *et al.* 1990) and rare minerals such as erdite, kogarkoite, tugtupite, vitusite-(Ce), makatite, thalcusite, chkalovite, sazhinite-(Ce), and sidorenkite. Silinaite occurs as clear tabular crystals (up to 2 mm across), in cavities in ussingite, closely associated with a mixture of dark green terskite and yellow UK38, pseudomorphous after an unknown dodecahedral mineral. In one case, it is associated with serandite, vuonnemite with a surface alteration to halite and an unidentified sodium sulfate.

In another xenolith, silinaite was found as small white fibrous clusters, as white, poorly formed, prismatic crystals, and as chalky to earthy or powdery patches in cavities in villiaumite or aegirine. Thermonatrite is ubiquitous in the xenoliths as a secondary efflorescence but, although rare, it was also observed as a primary mineral in the matrix. Other minerals of interest are revdite, chkalovite, sidorenkite, rasvumite, natrophosphate, vitusite-(Ce), UK38, UK53, UK55 group, UK63, and UK74.

The mineral is probably either a late-stage mineral formed during the emplacement of the sodalite syenite or a contact metamorphic or metasomatic mineral formed during the emplacement of the nepheline syenite.

Physical and Optical Properties

Silinaite is white to colorless, with a white streak, opaque to translucent or transparent, with a vitreous to earthy luster. The Mohs hardness is about 4.5. The mineral is brittle. It has a conchoidal fracture, perfect {001}, good {010} and distinct {110} cleavages. The only recognizable form on the tabular crystals is {001}. The density, measured by flotation in bromoform diluted with acetone, is 2.24(1) g/cm^3. Silinaite does not fluoresce in ultraviolet light. The mineral dissolves slowly in concentrated HCl and HNO_3, and more slowly in H_2SO_4, leaving a gelatinous residue.

The optical study of silinaite was carried out in sodium light (λ 589 nm) on a spindle stage using crystals previously oriented by X-ray goniometry. Silinaite is biaxial positive, with α 1.515(1), β 1.516(1), γ 1.518(1), $2V$(meas.) 64(1)°, $2V$(calc.) 71°.

The optical orientation is $X = b$, $Y \wedge c = 16°$ in the acute β angle. The mineral is nonpleochroic and displays strong inclined dispersion, with $r > v$. The fibrous variety displays both positive and negative elongation, which suggests that the fiber axis is c.

X-Ray Crystallography

An X-ray precession study of single crystals of silinaite showed the mineral to be monoclinic. The cell parameters obtained from single-crystal diffractometer data and refined by a least-squares method are: a 5.061(1), b 8.334(2), c 14.383(3) Å and β 96.67(2)°. The extinctions are consistent with the space groups $A2/n$ or An. However, $A2/n$ is the correct space group, as determined by crystal-structure analysis (Grice 1991). The A cell was chosen, according to the common practice for layer silicates, so that the perfect cleavage is described as {001}.

X-ray powder photographs were prepared using a 114.6-mm Gandolfi camera and Ni-filtered Cu$K\alpha$ radiation. The observed Gandolfi diffraction pattern is compared in Table 1 with the powder pattern calculated from the crystal structure (Grice 1991). Despite some discrepancies between the observed and calculated intensities, the agreement in general is very good. In addition to the inaccuracy of visual estimation of intensities, the discrepancies probably also reflect the fact that the recording geometry of the Gandolfi camera does not provide equal opportunity for all lattice planes to satisfy the Bragg equation.

Twinning in silinaite has been observed both under the polarizing microscope and on the precession photographs. The composition plane of the twin is parallel to (001). The twin law may be described either by (001) as a twin plane or by $[110]_{180°}$ as a twin axis. The former may be eliminated by structural considerations (Grice 1991).

Chemical Composition

Silinaite was analyzed using wavelength dispersion on a Cambridge Microscan MK5 electron microprobe, with an operating voltage of 20 kV and a beam current of 20 nA. A defocused 10-μm beam was used to minimize volatilization. A series of short counts was used for Na to maximize X-ray counts. Albite (Na$K\alpha$, Si$K\alpha$) and Kakanui hornblende (Ca$K\alpha$, Al$K\alpha$) were used as standards. K, Fe, Mg, Mn, Ti and F were sought but not detected. The averaged analytical results from eight spots on two crystals are shown in column 1, Table 2. A grain of silinaite from a different specimen was analyzed on a JEOL 733 Superprobe with Tracor-Northern 5600 automation, housed at the Canadian Museum of Nature. The operating voltage was 15 kV with a beam current of 15 nA. A scanning beam over an area of approximately 100 μm was used to minimize damage to the sample. B, N, Al, and Fe scans were performed, but these elements were not detected. Albite (Si$K\alpha$, Na$K\alpha$) and diopside (Ca$K\alpha$) were used as standards. The results are given in column 2, Table 2. The two sets of data are in excellent agreement, except that the total of the second set of data is slightly low, perhaps owing to a poorer polish of the sample.

TABLE 2. COMPOSITION OF SILINAITE

		1	2	3
SiO_2	wt.%	58.54	58.72	59.45
Al_2O_3		0.01	0.00	--
CaO		0.14	0.42	--
Na_2O		14.96	13.66	15.33
Li_2O		(7.28)	(7.25)	7.39
H_2O		(17.56)	(17.47)	17.83
Total		98.49	97.52	100.00

1. MK5 electron microprobe, Carleton University. Analyst: Peter C. Jones. Li_2O and H_2O assumed stoichiometric.
2. JEOL 733 Superprobe, Canadian Museum of Nature. Analyst: R. A. Gault. Li_2O and H_2O assumed stoichiometric.
3. Theoretical composition for $NaLiSi_2O_5 \cdot 2H_2O$.

The electron-microprobe analyses of silinaite show a deficiency of 26–27 wt.%, which must be due to the presence of light elements or water not detected by the microprobe. As the amount of material available is insufficient for analysis of light elements by conventional wet-chemical methods, a crystal-structure analysis was carried out (Grice 1991) using 792 unique observed reflections. The structure was refined to $R = 3.0$ and $R_w = 2.6\%$. The missing components were found to be Li and H_2O. Li was identified from its electron density (scattering power), cation-to-oxygen interatomic distances [1.990(3) and 1.997(3) Å] in tetrahedral coordination, and its valence sum (0.93 v.u.). The H_2O molecules were recognized by their valence sum (0.35 v.u.), oxygen–hydrogen configurations, and hydrogen bonding to adjacent oxygen atoms. The structure analysis shows that silinaite is a phyllosilicate with the structural formula $NaLiSi_2O_5 \cdot 2H_2O$ and $Z = 4$. On this basis (O = 7), the empirical formulas calculated from data sets 1 and 2 in Table 2 are $(Na_{0.99}Ca_{0.01})LiSi_{2.00}O_5 \cdot 2H_2O$ and $(Na_{0.91}Ca_{0.02})LiSi_{2.02}O_5 \cdot 2H_2O$, respectively; Li and H_2O are taken to be present in stoichiometric proportions. Density values calculated from these empirical formulas are 2.23 and 2.22 g/cm^3. That calculated from the ideal formula is 2.23 g/cm^3, in excellent agreement with the measured density value of 2.24(1) g/cm^3.

Discussion

The chemical formula of silinaite, derived from

the crystal-structure analysis, is well supported by the agreement between partial electron-microprobe analyses and the calculated composition, measured and calculated densities, and the excellent compatibility of chemical and physical data shown by Gladstone–Dale calculations (Mandarino 1981). These gave $1-(K_P/K_C) = 0.025$. A member of the CNMMN, IMA pointed out to us that silinaite is probably isomorphous with searlesite, $NaBSi_2O_5(OH)_2$. Although both silinaite and searlesite are single-layer silicates, they differ in the topology of the layers (Grice 1991). Thus silinaite is unique in both chemical composition and structure.

Acknowledgements

We thank T.S. Ercit for assistance with the electron-microprobe analysis at the Canadian Museum of Nature, P.C. Jones for electron-microprobe analyses performed at Carleton University, and R.P. Conlon for technical assistance. We also thank A.C. Roberts and D.C. Harris, whose comments greatly improved the manuscript. The work is supported by NSERC operating grant A5113 to GYC.

References

Chao, G.Y., Conlon, R.P. & Van Velthuizen, J. (1990): Mont Saint-Hilaire unknowns. *Mineral. Rec.* **21**, 363-368.

Grice, J.D. (1991): The crystal structure of silinaite, $NaLiSi_2O_5 \cdot 2H_2O$; a monophyllosilicate. *Can. Mineral.* **29**, 363-367.

Mandarino, J.A. (1981): The Gladstone–Dale relationship. IV. The compatibility concept and its application. *Can. Mineral.* **19**, 441-450.

Received September 26, 1990, revised manuscript accepted November 9, 1990.