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SABINAITE: A NEW OCCURRENCE AND NEW DATA†

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ABSTRACT

At Mont St. Hilaire, Quebec, sabinaite occurs with albite, microcline, dawsonite, analcime, sodalite, pectolite, dolomite and aegirine in cavities in the sodalite syenite. Electron-microprobe analyses gave ZrO_2 40.64, HfO_2 0.45, TiO_2 10.91, Na_2O 19.53, CaO 0.02, CO_2 27.56 (calc.), sum 99.11 wt.%, corresponding to $Na_{4.02}(Zr_{1.99}Hf_{0.01})(Ti_{0.87}Zr_{0.12})O_4(CO_3)_4$. The new ideal formula is $Na_4Zr_2TiO_4(CO_3)_4$. $Z = 4$. $D_{calc} = 3.48$ g/cm^3. Precession photographs show the mineral to be monoclinic, *C2/c* or *Cc*, with *a* 10.171(5), *b* 6.623(4), *c* 17.976(9) Å, β 94.32(4)°. Crystals are tabular on (001), with {001}, {010}, {100} and {110} forms. The {001} cleavage is perfect and {010} distinct. Optically, the mineral is colorless, transparent, with vitreous luster; biaxial positive, α 1.720(2), β 1.79(1), γ 1.90(calc.), $2V = 82(1)°$, all in Na light. Orientation: $Y = b$, $X \wedge c = 13°$ in the obtuse β. Dispersion moderate, with $r > v$.

Keywords: sabinaite, Mont St. Hilaire, Quebec, new data.

SOMMAIRE

Au mont St-Hilaire (Quebec), la sabinaïte se trouve associée à albite, microcline, dawsonite, analcime, sodalite, pectolite, dolomite et aegyrine dans les cavités de la syénite à sodalite. Les analyses à la microsonde électronique donnent: ZrO_2 40.64, HfO_2 0.45, TiO_2 10.91, Na_2O 19.53, CaO 0.02, CO_2 27.56 (calculé), total 99.11% (en poids), ce qui correspond à la formule $Na_{4.02}(Zr_{1.99}Hf_{0.01})(Ti_{0.87}Zr_{0.12})O_4(CO_3)_4$. La formule idéale révisée serait donc $Na_4Zr_2TiO_4(CO_3)_4$. $Z = 4$. $D_{calc} = 3.48$. Les clichés de précession révèlent un minéral monoclinique, *C2/c* ou *Cc*, *a* 10.171(5), *b* 6.623(4), *c* 17.976(9) Å, β 94.32(4)°. Les cristaux sont tabulaires, aplatis sur (001), montrant les formes {001}, {010}, {100} et {110} . Le clivage est parfait suivant {001} , distinct suivant {010}. Optiquement, la sabinaïte est incolore, transparente et d'éclat vitreux; biaxe positive, α 1.720(2), β 1.79(1), γ 1.90(calc.), $2V = 82(1)°$, (mesures à la lumière de Na). Orientation: $Y = b$, $X \wedge c = 13°$ dans l'angle obtus de β. Dispersion moyenne, $r > v$.

(Traduit par la Rédaction)

Mots-clés: sabinaïte, mont St-Hilaire (Québec), données nouvelles.

INTRODUCTION

Sabinaite, an anhydrous carbonate of sodium, zirconium and titanium, was first found at the Francon quarry in Montreal and described by Jambor *et al.* (1980). The mineral has since been found by Elsa and Làszló Horváth in small amounts with albite, microcline, dawsonite, analcime, sodalite, pectolite, dolomite and aegirine in cavities in the sodalite syenite at Mont St. Hilaire, Quebec. Electron-microprobe analyses, X-ray and optical studies of these well-formed crystals of sabinaite yielded new data that characterize the mineral more fully.

X-RAY CRYSTALLOGRAPHY

Precession photographs of sabinaite from Mont St. Hilaire show the mineral to be monoclinic, space group *C2/c* or *Cc*. The cell parameters measured from these photographs and then refined by a least-squares method using powder-diffraction data obtained with a Gandolfi camera (Table 1) are *a* 10.171(5), *b* 6.623(4), *c* 17.976(9) Å, β 94.32(4)°. The powder pattern was indexed on the basis of the precession photographs, using only the strong single-crystal reflections.

Jambor *et al.* (1980) derived a monoclinic cell for sabinaite; they found *a* 6.605(3), *b* 10.186(5), *c* 37.94(5) Å, β 90°, where *a* and *b* were based on electron-diffraction data and *c* and β were calculated from X-ray powder-diffraction data. Their *a* and *b* apparently correspond respectively to *b* and *a* of the present cell but a simple rational relationship between their *c* and the present *c* cannot be established. Their *c* is dimensionally close to $2c-a$ (38.09 Å) in the present cell but this leads to a β angle of 109.74°.

PHYSICAL AND OPTICAL PROPERTIES

Sabinaite from Mont St. Hilaire is colorless, transparent and vitreous. Solid inclusions of irregular shape and well-formed rhombs with strong negative relief are common. The crystals, averaging 0.4 × 0.3 × 0.05 mm, are tabular, flattened on *c* and slightly elongate along *a*. Forms present are {001}, {010}, {100} and {110} (Fig. 1). The crystal morphology indicates the presence of a centre of symmetry; the most probable space-group is, therefore, *C2/c*. The presence of the perfect {001} and distinct {010}

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

	Mont St.Hilaire[1]			Francon[2]		
hkl	d_{cal}(Å)	d_{obs}(Å)		d_{cal}(Å)	d_{obs}(Å)	*I*
002	8.962	8.96	100	8.945	8.97	10
111	5.238	5.23	5			
200	5.071	5.08	10	5.076	5.10	1
20$\bar{2}$	4.563	4.57	5	4.567	4.57	< ½
004	4.481	4.48	25	4.472	4.48	2
202	4.278	4.28	20	4.276	4.30	1
20$\bar{4}$	3.491	3.488	5			
020	3.312	3.305	10	3.306	3.307	1
					3.277	< ½B
021	3.258	3.251	50	3.251	3.252	2
022	3.107	3.107	10			
310	3.011			3.012	3.009	1
006	2.989	2.990	50	2.982	2.991	6
311	2.938	2.945	20	2.938	2.942	< ½B
023	2.897	2.901	3			
312	2.798	2.805	5			
31$\bar{3}$	2.765			2.766	2.768	< ½
22$\bar{1}$	2.757	2 763	10			
					2.742	< ½B
221	2.723	2.727	25	2.720	2.724	1
20$\bar{6}$	2.663	2.662	10	2.661	2.665	< ½
313	2.619			2.618		
222	2.619	2 624	25	2.616	2 628	< ½B
40$\bar{2}$	2.489	2.492	5	2.492	2.494	1
402	2.393	2.390	10			
008	2.241			2.236		
22$\bar{5}$	2.238	2 239	40	2.236	2 243	1
130	2.157	2.155	10	2.154	2.150	1
					2.126	< ½B
20$\bar{8}$	2.109	2.106	20	2.107	2.109	1
31$\bar{7}$	2.019			2.018		
42$\bar{1}$	2.014	2.017	45	2.014	2.017	5
420	2.013			2.013		
208	1.995					
226	1.992					
42$\bar{2}$	1.990	1 992	10			
421	1.986					
51$\bar{1}$	1.943	1.947	10	1.945	1.946	2
11$\bar{9}$	1.900					
317	1.889	1 893	15			
028	1.856			1.852		
330	1.849			1.847		
331	1.847	1 850	25	1.845	1 847	6
227	1.844			1.841		
331	1.831			1.829		
332	1.825	1 827	15	1.824	1 824	2
513	1.807	1.811	2			
332	1.796			1.794		
00.10	1.793	1 795	35	1.789	1 795	3
13$\bar{6}$	1.762	1.761	2			
136	1.736			1.733		
514	1.735	1.735	10	1.735	1.730	< ½
33$\bar{4}$	1.734			1.733		
31$\bar{9}$	1.715					
425	1.712					
228	1.709	1 711	15			
029	1.707					
600	1.690			1.692	1.693	< ½
334	1.685	1.687	15	1.682		
51$\bar{6}$	1.683			1.684	1 687	3
33$\bar{5}$	1.671	1.668	2			
2.0.10	1.651			1.648		
22$\bar{9}$	1.650	1.648	10	1.648	1.646	5
041	1.649			1.646		
60$\bar{4}$	1.622			1.624	1.624	< ½
408	1.620					
319	1.612	1 615	5			
51$\bar{7}$	1.603			1.603		
33$\bar{6}$	1.602	1 601	10	1.600	1 601	< ½
24$\bar{1}$	1.571	1.571	5	1.569	1.569	< ½
336	1.546					
604	1.546	1 546	15			
243	1.513	1.512	2			
00.12	1.494					
621	1.492	1 495	10			
622	1.469	1.463	2			
62$\bar{4}$	1.457					
33$\bar{8}$	1.456	1 457	10			

[1] 114.6 mm Gandolfi camera, CuK_α radiation, λ = 1.5418Å, Si internal standard, visual intensities.
[2] Data from Jambor *et al.* (1980) reindexed on a = 10.181(6), b = 6.612(3), c = 17.94(1)Å, β = 94.39(5)°.

cleavages confirms the observations of Jambor *et al.* (1980) on sabinaite from the Francon quarry.

The optical properties of sabinaite from Mont St. Hilaire were determined in sodium light using a spindle stage and crystals previously oriented by the X-ray-precession method. The mineral is biaxial positive, in contrast to sabinaite from Francon, which was reported to be biaxial negative (Jambor *et al.* 1980). The indices of refraction are α 1.720(2), β 1.79(1). The γ index could not be determined as in the high-index oil a film of minute particles rapidly formed on the surface of the crystal. The calculated value for γ is 1.90. The $2V$ angle is 82(1)°, determined directly by measuring the angle between the optic axes. The orientation is $Y = b$, $X\Lambda c = 13°$ in the obtuse angle of β. The mineral shows moderate inclined dispersion with $r > v$.

Chemical Formula

Sabinaite from Mont St. Hilaire was analyzed by means of an electron microprobe, using a defocused beam. An initial energy-dispersion scan confirmed the presence of Na, Zr, Ti and Hf. Subsequent quantitative analyses were carried out using the following standards: synthetic ZrO_2 (Zr), synthetic $(Zr,Hf)O_2$ (Hf), albite (Na) and hornblende (Ti,Ca). F was sought but not detected. CO_2 was not determined because of the small amount of sample available. The data given in Table 2 represent the average results of five analyses on different spots of the same crystal. The averaged analytical data compare well with those for sabinaite from Francon (Jambor *et al.* 1980).

In the light of the new cell-dimension data for sabinaite, the chemical formula proposed by Jambor *et al.* (1980) presents two serious problems. Firstly, the calculated density (3.61 g/cm^3) based on the new cell is much too high in comparison with the measured density of 3.36 g/cm^3. Secondly, the cell content of 18 Na, 9 Zr and 18 non-carbonate oxygen atoms is incompatible with the space group *C*2/*c* or *Cc*. Hence a new formula must be sought. Calculations of the cell content based on the mass–volume–density relationship shows that the Na:Zr:Ti:C proportions are close to 4:2:1:4 for 16 oxygen atoms. The formula for sabinaite from Mont St. Hilaire was therefore calculated on the basis of 8 oxygen atoms per formula, assuming a stoichiometric amount of CO_2. The calculated formula is $Na_{4.02}(Zr_{1.99}Hf_{0.01})(Ti_{0.87}Zr_{0.12})O_4(CO_3)_4$, with Z = 4. This formula requires 27.56 wt.% CO_2, which compares well with the analytical value of 27.1% for sabinaite from Francon. The density calculated from this empirical formula is 3.48 g/cm^3. Similarly, the analysis of sabinaite from Francon corresponds to $(Na_{4.18}Ca_{0.02})(Zr_{1.99}Hf_{0.01})Ti_{0.94}O_{4.14}(CO_3)_{3.86}$, with $Z = 4$. The density calculated for sabinaite from Francon, based on the new cell-parameters (Table 1), is 3.44 g/cm^3, in good agreement with the meas-

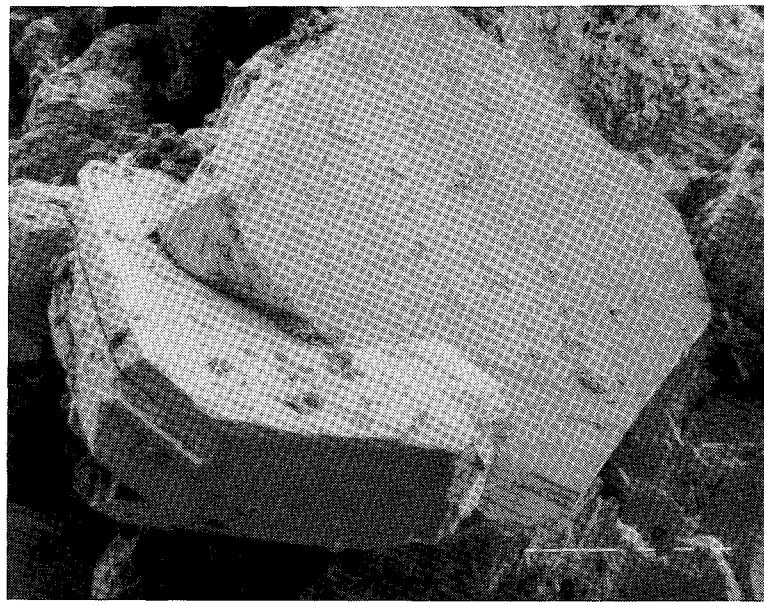

FIG. 1. Sabinaite crystals from Mont St. Hilaire, Quebec. The scale bar is 0.1 mm. SEM photomicrograph.

ured density of 3.36 g/cm^3 reported by Jambor *et al.* (1980). The ideal formula for sabinaite is, therefore, $Na_4Zr_2TiO_4(CO_3)_4$.

The chemical molar refractivity K_C (Mandarino 1979), based on the new empirical formula and the constants given by Mandarino (1981), are 0.226 and 0.228, respectively, for sabinaite from Mont St. Hilaire and Francon. The K_P/K_C value (Mandarino 1979) for sabinaite from Mont St. Hilaire, based on the calculated density, is 0.230/0.226 = 1.018 whereas the K_P/K_C value for sabinaite from Francon, based on the observed (3.36 g/cm^3) and calculated (3.44 g/cm^3) densities, is 0.237/0.228 = 1.039 and 0.232/0.228 = 1.017, respectively. The compatibility of the chemical and physical data for sabinaite is, therefore, excellent to superior (Mandarino 1979).

TABLE 2. COMPOSITION OF SABINAITE

	(1)	(2)	(3)
ZrO_2 (Wt.%)	40.64	39.1	39.34
HfO_2	0.45	0.47	
TiO_2	10.91	12.05	12.76
Na_2O	19.53	20.7	19.79
CaO	0.02	0.2	
CO_2	(27.56)	27.1	28.10
	99.11	99.57	99.99

(1) Mont St. Hilaire, Quebec, CO_2 calculated.
(2) Francon quarry, Montreal, Quebec, Jambor *et al.* (1980).
(3) Ideal $Na_4Zr_2TiO_4(CO_3)_4$.

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