CORDYLITE FROM MONT ST. HILAIRE, QUEBEC

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Cordylite, $BaCe_2(CO_3)_3F_2$, was first described by Flink (1901) from Narssarssuk, Greenland, where it occurred in small quantities with aegirine, synchysite, neptunite and ancylite in the pegmatite veins. The mineral has not been found outside Greenland until recently, when one of the unknown minerals, UK12 (Chao *et al.* 1967), from Mont St. Hilaire, Quebec, was identified as cordylite.

Only two small crystals of this rare mineral have been found on one specimen from the pegmatite dykes in nepheline syenite at Mont St. Hilaire. The crystals are poorly formed with hexagonal tabular habit in contrast to the prismatic habit of cordylite crystals from Greenland. The crystals display a rough pinacoid, prism and at least one pyramid (Fig. 1), and they measure about 2 mm across the pinacoid and 1.0 mm along the prism. The associated minerals are analcime, aegirine, albite with minor amounts of biotite, rinkite, calcite, apatite, catapleiite, pyrochlore and pyrophanite. The crystals are pale yellow with waxy luster on the crystal faces and vitreous luster on freshly exposed surfaces. The mineral is brittle with conchoidal fracture and

has a good cleavage parallel to the basal pinacoid. The hardness is about 4½. The mineral is soluble with effervescence in HCl at room temperature. The optical properties of cordylite from Mont St. Hilaire are similar to those of the mineral from Greenland except that the refractive index ω is considerably higher (Table 1).

Precession and Weissenberg x-ray studies of five fragments from one crystal confirmed the space group symmetry, $P6_3/mmc$ and $P\bar{6}2c$, reported for cordylite from Greenland (Donnay & Donnay 1955). Two weak diffuse reflections, 111 and 221, that violate the extinction rules, were observed on the x-ray photographs taken with MoKα radiation. These reflections were interpreted as due to Renninger effect because they were not observed on photographs taken with CuKα radiation. If these reflections were real, the space group for cordylite would become $P6/mmm$, $P\bar{6}2m$, $P\bar{6}m2$, $P6mm$ or $P622$. The cell parameters of cordylite from Mont St. Hilaire, obtained by least-squares refinement with powder diffraction data, are similar to those of cordylite from Greenland (Table 1). The *a* parameter reported by Oftedal (1931) for the Green-
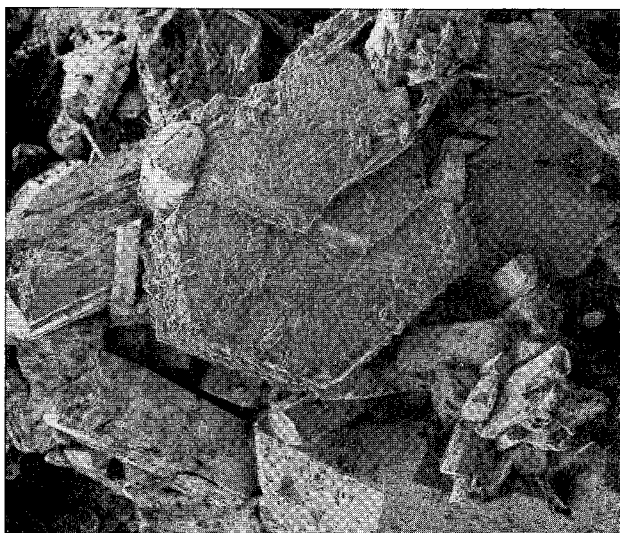

FIG. 1. Scanning electron photomicrograph of cordylite crystal from Mont St. Hilaire, Quebec (center, approximately 2 mm in diameter).

TABLE 1. PHYSICAL AND OPTICAL PROPERTIES OF CORDYLITE

	Narssarssuk, Greenland				Mont St. Hilaire, Que.
	Flink (1901)	Bøggild (1953)	Oftedal (1931)	Donnay & Donnay (1955)	This Study
Symmetry	Hexagonal	Hexagonal	Hexagonal	$P6_3/mmc, P\bar{6}2c$	$P6_3/mmc, P\bar{6}2c$
a Å	-	-	4.35	5.100(15)	5.098(1)
c Å	-	-	22.8	23.08(7)	23.050(5)
$a:c$	$a:4a=1:4.5152^\dagger$	-	1 : 5.25	1 : 4.525	1 : 4.5214
z	-	-	-	2	2
ω	-	1.7640	-	-	1.773(2)††
ε	-	1.5772	-	-	1.576(1)
D_{obs} g/cm³	4.31	-	-	4.10	-
D_{calc} g/cm³	-	-	-	4.06	3.97

† Donnay & Donnay (1955)
††Determined at 25°C on a spindle stage in Na-light using a crystal fragment pre-oriented by x-ray goniometry.

land cordylite is related to the *a* parameter reported in this paper by a factor of csc60°. The x-ray powder diffraction patterns of cordylite from the two localities are nearly identical (Table 2).

Electron microprobe analysis of cordylite from Mont. St. Hilaire is presented in Table 3. The contents of CO_2 and H_2O were not determined because of the limited amount of material available. Assuming a stoichiometric amount of CO_2, the analysis was calculated on the basis of eight cationic charges per formula to

$(Ba_{0.92}Ca_{0.07}Sr_{0.04})(Ce_{1.37}La_{0.59}Th_{0.01})(CO_3)_3F_{1.58}$.

The deficiency in F in the empirical formula, as compared with the ideal formula $BaCe_2(CO_3)_3$

TABLE 2. X-RAY POWDER DIFFRACTION DATA OF CORDYLITE

		Mont St. Hilaire Quebec		Narssarssuk Greenland*	
hkl	d(calc.)Å†	d(obs.)Å††	I	d(obs.)Å	I
002	11.525	11.533	½	-	
004	5.763	5.766	3	5.776	5
101	4.336	4.336	8	4.342	10
102	4.123	4.128	6	4.125	9
006	3.842	3.843	8	3.847	9
104	3.505	3.510	9	3.511	10
105	3.189	3.193	10	3.194	10
106	2.898	2.899	5	2.903	7
110	2.549	2.550	8	2.552	10
108	2.413	2.414	½	-	
114	2.331	2.330	½	2.335	1
0·0·10	2.305	2.306	2	2.306	2
109	2.215	2.216	6	2.221	7
201	2.197	2.196	6	2.200	9
202	2.168	2.167	6	2.171	9
116	2.124	2.122	7	2.128	10
204	2.061	2.061	3	2.064	7
1·0·10	2.043	2.040	8	2.048	9
205	1.991	1.989	6	1.994	9
0·0·12	1.921	1.921	1	1.925	3
118	1.909	1.907	6	1.912	7
1·0·11	1.893	1.891	½	1.898	1
207	1.834	1.832	½	1.835	2
1·0·12	1.761	1.760	1	1.763	3
1·1·10	1.710	1.707	1	1.711	3
211	1.664	1.667	1	1.664	5
0·0·14	1.646	1.648	1	1.653	5
213	1.631	1.630		1.633	4
214	1.603	1.604	2	1.605	5
2·0·10	1.594	1.592	1	1.596	4
215	1.569	1.569	3	1.570	5
1·1·12	1.534	1.535	1	-	
2·0·10	1.520	1.518	½	1.522	1
300	1.472	1.472	2		
1·0·15	1.451	1.451	2		
219	1.398	1.398	2		
1·1·14	1.383	1.382	2		
1·0·16	1.370	1.371	1		
2·1·10	1.352	1.351	2		
2·1·11	1.305	1.306	1		

† Calculated from cell parameters of cordylite from Mont St. Hilaire.

††114.6mm camera, CuKα radiation, λ=1.5418Å, Si standard, visual I.

* Data provided by O.V. Petersen. Guinier-Hägg focusing camera, curved-crystal monochromator, CuKα radiation, λ=1.54051Å, quartz standard.

TABLE 3. CHEMICAL ANALYSES OF CORDYLITE

	1	2
Ce_2O_3	23.72	35.83
La_2O_3	⎱	15.41
Yb_2O_3	⎰ 25.67	0.08
Dy_2O_3,etc.		n.d.
Y_2O_3	tr	n.d.
ThO_2	0.30	0.26
FeO	1.43	n.d.
BaO	17.30	22.54
SrO	-	0.58
CaO	1.91	0.66
H_2O	0.80	-
CO_2	23.47	(20.97)
F	(4.87)	4.75
Cl	-	n.d.
Insoluble	2.58	-
	102.05	101.08
O ≡ F	2.05	2.00
Total	100.00	99.08

1. Cordylite from Narssarssuk, Greenland. Fluorine determined by difference (Flink 1901)

2. Cordylite from Mont St. Hilaire, Quebec. Electron microprobe analysis at 15 kv. Standards: synthetic $LaAlO_3$, $Yb_3Ga_5O_{12}$, $Dy_3Al_5O_{12}$, $Y_3Fe_5O_{12}$, NaCl, and bastnaesite, fluorite, benitoite, celestite, ilmenite, and Th-metal. Computer program by Rucklidge & Gasparrini (1969). CO_2 assumed to be stoichiometric.

F_2, is most likely due to the omission of H_2O in the analysis. The H_2O is probably present in the mineral as a hydroxyl group. With $Z = 2$ the density of cordylite from Mont St. Hilaire calculated from the analysis, is 3.97 g/cm³ and is somewhat lower than the density reported by other authors for cordylite from Greenland (Table 1).

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