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EUDIALYTE FROM THE KIPAWA LAKE AREA, TEMISCAMINGUE CO., QUEBEC

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This note describes the chemical, optical and *x*-ray properties of eudialyte from a locality on the Kipawa River close to Sairs Lake, about 22 miles east of the town of Kipawa in Temiscamingue Co., Quebec. Eudialyte is a fairly rare, complex zirconium-iron-sodium-rare earth silicate occurring in pegmatite and syenitic peralkaline rocks of both undersaturated and oversaturated types. Among the best known localities of eudialyte are the Julianehaab district of Greenland; the Lovozero massif, Kola peninsula, U.S.S.R.; the Langesundfiord of Norway; and the Magnet Cove district, Arkansas, U.S.A. In Canada eudialyte has been reported from the Seal Lake area, Labrador and Pontiac Co., Quebec (Hicks 1958), and as one of a suite or rare minerals from Mt. St. Hilaire, Quebec (Chao *et al.* 1967; Perrault *et al.* 1969).

Description of Sample and Geological Setting

The eudialyte occurs as pink colored granular aggregates in syenitic rocks. Foliation in the syenites is defined by bands of dark green clinopyroxene and greenish blue amphibole alternating with bands of light colored feldspar. The eudialyte is present in both the mafic and felsic bands, and may constitute up to 10% of the rock. Other minerals present in the collected rock samples are thorite (never greater than 5% of the rock), occurring as metamict crystals mainly within the felsic bands; and occasional fluorite and magnetite. Some other rare minerals were suspected in some of the samples but were not identified.

The geology of the Kipawa Lake area has been described by Osborne & Morin (1962). The rocks are of Grenville age and in the vicinity of

Sairs Lake have been grouped under four headings: — pink gneissic granite; grey biotite-feldspar gneisses; quartzite kyanite and garnet gneisses; and alkaline syenite. The syenites containing eudialyte occur on the steeply dipping eastern flank of the Kipawa syncline, a prominent structural feature of the area.

PETROGRAPHY OF THE SYENITES

Examination of the syenite in thin section shows the principal felsic minerals to be plagioclase and microcline; and the principal mafic minerals to be pyroxene and amphibole. The plagioclase is close to albite in composition. Optical and *x*-ray determinations on the pyroxene and amphibole showed them to be sodic varieties close to aegirine-augite and arfvedsonite respectively. Neither quartz nor nepheline were detected, indicating the rock to be a saturated syenite with possible peralkaline affinities as suggested by the sodium-rich pyroxene and amphibole.

The eudialyte is easily recognized by its mottled birefringence. It is weakly pleochroic from pink to colorless, and has refractive indices of $\varepsilon = 1.597$, $\omega = 1.594$. Occasional inclusions of amphibole, pyroxene and feldspar occur within eudialyte. Thorite is distinguished by its high relief, very weak anisotropism and fine concentric haloes presumably caused by radioactivity.

CHEMISTRY

A pure sample of eudialyte for chemical *x*-ray powder diffraction analyses was obtained by hand picking a coarsely crushed fraction of the host rock. Purity was checked by optical and *x*-ray diffraction methods.

The chemical analysis of the Kipawa Lake eudialyte is given in Table 1. All oxides believed to occur in amounts greater than 0.01% were determined. By comparison with other eudialyte analyses (*cf.* Gerasimovskii *et al.* 1966) elements occurring in lesser amounts may include Li, Be, Ga, Th, U, Zn and Pb. Rare-earth oxides and ZrO_2 were determined by two independent laboratories. The principal rare-earth oxides in order of relative abundance were yttrium, cerium, lanthanum, neodymium, dysprosium and ytterbium.

The specific gravity of 2.90, determined with a Berman balance, is in good agreement with other published values.

In Table 1 the unit cell content is derived from the analysis using the density and cell dimensions measured on this material. The cell content gives a total of 222.62 divalent anions and 4.75 monovalent anions. In Table 1, O and H have been combined giving 206.46 O^{2-} and 20.91 (OH, Cl,F) or with Z = 12, 18.74 anions.

To our knowledge the structure of eudialyte has not been determined and there seems to be no general agreement as to the number of anions (O, OH, Cl, F) in the formula, estimates ranging from 18 to 20. In the last

TABLE 1. EUDIALYTE : ANALYSIS *, CELL CONTENT, FORMULA

Oxides	*Analysis*	*Unit Cell Content*		Atom Content —			*Ideal Formula*	
	Weight	Oxide Content	Atom			Z = 12	19 anions	18 anions
SiO_2	50.35	74.33	Na	35.88	36.68	3.05	3.08	2.92
Al_2O_3	0.44	0.38	K	0.80				
Fe_2O_3	0.19	0.11	Ca	15.41	24.80	2.06	2.08	1.98
FeO	2.41	2.98	*R.E.*	4.36				
MgO	0.13	0.28	Fe^{2+}	2.98				
CaO	9.74	15.41	Mn	1.68				
Na_2O	12.53	17.94	Mg	0.28				
K_2O	0.43	0.40	Sr	0.09				
H_2O (total)	1.64	8.08	Zr	8.50	10.36	0.86	0.87	0.83
TiO_2	0.38	0.42	Al	0.76				
ZrO_2	11.80	8.50	Nb	0.46				
P_2O_5	0.03	0.02	Ti	0.42				
Cl	1.47	3.68	Fe^{3+}	0.22				
F	0.23	1.07	Si	74.33		6.18	6.23	5.92
MnO	1.34	1.68	O	206.46		17.10	17.25	16.33
SrO	0.109	0.09	OH	16.16				1.29
Nb_2O_5	0.69	0.23	Cl	3.68	20.91	1.74	1.75	0.29
R.E. **	6.40	2.18	F	1.07				0.09
	100.309							
less O for F, Cl	—0.43							
	99.88							

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* Analysis by K. Ramlal except ZrO_2 and Nb_2O_5 by X-ray Assay Laboratories Ltd., and *R.E.* oxides by École Polytechnique.

** Approximate order of abundance of *R.E.* oxides: 2 percent Y_2O_3, 0.5 — 1.0 percent CeO_2, La_2O_3, 0.5 percent Nd_2O_3, Dy_2O_3, Yb_2O_3 — (average atomic weight used in calc. 156).

two columns of Table 1 the ideal formula is given for 19 cations as suggested by Gossner (1930) and by Strunz (1970), and also for 18 cations. The former is closer to the cell content and is in fair agreement with the formula proposed by Gossner and by Hey (1962), $Na_4(Ca,Fe)_2ZrSi_6O_{17}(OH,Cl)_2$ although Na and Zr are low and Si is high.

Both formulae show a deficiency of the alkali, alkaline earth and rare earths possibly caused by analytical errors and/or the presence of possible water or chlorine molecules in these sites. If eudialyte has a structure resembling beryl, it may contain hollow channels capable of containing H_2O or possibly Cl. The fairly large amounts of H_2O and Cl in the analysis and its large unit cell may lend some support to this suggestion.

Comparison of the chemistry of the Kipawa Lake eudialyte with other eudialytes is shown in Table 2. The data of Vlasov (1964) and Gerasimov-

TABLE 2. COMPARISON OF KIPAWA LAKE WITH OTHER EUDIALYTES.

	A	B	C[1]	D[1]
SiO_2	50.35	47.55	48.23(9)	49.55(10)
Al_2O_3	0.44	—	1.60(3)	—
FeO	2.41	3.50	4.43(8)	2.75(10)
Fe_2O_3	0.19	1.11	1.99(5)	1.18(9)
CaO	9.74	6.15	10.31(8)	—
MgO	0.13	—	0.17(9)	0.27(10)
Na_2O	12.53	11.39	13.27(9)	13.46(10)
K_2O	0.43	2.70	0.54(9)	0.74(10)
H_2O (total)	1.64	1.56	1.91(8)	1.90(10)
TiO_5	0.38	0.14	0.40(9)	—
P_2O_5	0.03	—	0.40(9)	—
MnO	1.34	5.44	1.91(9)	2.11(10)
SrO	0.109	—	—	—
ZrO_2	11.80	12.50	13.05(9)	—
R.E. oxides	6.40	6.30	2.77(8)	—
Nb_2O_5	0.69	1.20	1.13(5)	—
Cl	1.47	0.68	1.18(9)	—
F	0.23	—	—	—

A — Present sample.
B — Eudialyte, Mt. St. Hilaire, P.Q. (after Perrault *et al.* 1969).
C — Average of 9 eudialytes from various localities (after Vlasov 1964).
D — Average of 10 eudialytes from U.S.S.R. (after Gerasimovskii *et al.* 1966).
[1] Number of samples available for average given in parentheses.

skii *et al.* (1966) for Russian and other European eudialytes indicates a fairly wide range of composition. The principal difference between the Kipawa Lake eudialyte and the other analyses are its low Fe_2O_3, Al_2O_3, Na_2O and MnO contents and its higher Cl, *R.E.* oxide and possibly SiO_2 contents. Comparison of the Mt. St. Hilaire (Perrault *et al.* 1969) and Kipawa Lake eudialytes indicates high K_2O, MnO and *R.E.* oxide and low CaO in the Mt. St. Hilaire sample. According to Vlasov (1964) high MnO is characteristic of eucolite.

X-RAY STUDY

Cell constants of the Kipawa Lake eudialyte were obtained by *x*-ray powder diffraction using Cu*K*α radiation and an internal Si standard. The pattern was indexed with the aid of the Powder Diffraction File (card 8-355). Some modification in *hkl* values was necessary to produce comparable *d* (obs) and *d* (calc) values. The cell size, based on hexagonal indexing, was obtained from twenty-five lines as shown in Table 3.

Comparison of the cell constants with two other eudialytes of unknown composition indicates a considerably smaller *a* parameter for the Kipawa Lake sample. Differences in cell sizes are likely in minerals with such complex chemistry.

CONCLUSIONS

This study does not warrant any conclusions regarding the origin of the Kipawa Lake eudialyte. The mineralogy of the host rock suggests it to be a slightly peralkaline syenite containing neither quartz nor nepheline. Both optical properties and chemistry indicate the eudialyte from the Kipawa Lake area to be fairly typical.

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TABLE 3. CELL PARAMETERS AND X-RAY DATA FOR KIPAWA LAKE EUDIALYTE. Radiation Cu$K\alpha$, Si internal standard

hkl	*d*Å (obs.)	*d*Å (calc.)	*I* (est.)
110	6.94	6.98	20
104	6.33	6.38	10
021	5.91	5.91	10
202	5.58	5.60	30
006	4.96	5.01	5
205	4.25	4.26	50
107	4.05	4.05	40
21.4	3.91	3.90	20
30.3	3.75	3.73	35
12.5	3.64	3.65	5
018	3.56	3.59	5
220	3.50	3.48	35
131	3.35	3.33	40
223	3.30	3.29	7
208	3.19	3.19	40
217	3.10	3.13	80
119	3.00	3.01	30
315	2.94	2.93	90
336	2.88	2.86	10
404	2.82	2.80	100
045	2.69	2.70	10
0,1,11	2.66	2.66	15
410	2.63	2.63	10
309	2.58	2.57	40
0,0,12	2.51	2.51	10

Cell Parameters of Eudialytes	a	c
Kipawa Lake (present study)	13.95 ± .02 Å	30.10 ± .02 Å
Kangerlaursuk, Julianehaab, Greenland		
(Zachariasen 1930)	14.31 Å	30.15 Å
(Gossner 1930)	14.34 Å	30.21 Å