# EUDIDYMITE FROM SEAL LAKE, LABRADOR, NEWFOUNDLAND

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ABSTRACT

Eudidymite is an accessory mineral in the soda-rich paragneiss at Seal Lake, Labrador. Its chemical composition is as follows: $Na_2O$ 12.20%, $K_2O$ 0.39%, BeO 10.15%, $SiO_2$ 73.56%, and $H_2O$ 3.62%; total 99.92%. The unit cell is slightly smaller than that of the Langesundfjord eudidymite; other physical and optical properties also show minor differences. These differences are believed to be related to variation in the Be:Si ratio in eudidymite.

## INTRODUCTION

Eudidymite, $NaBeSi_3O_7OH$, is a rare mineral that has been reported in alkaline syenites from only a few parts of the world, *viz.* Langesundfjord in Norway (Nordenskiöld, 1887), Narsarsuk in Greenland (Flink, 1901), the Kola Peninsula in the U.S.S.R. (Shilin & Semenov, 1957), and the Tallask Mountains in the Kirghiz Republic of the U.S.S.R. (Kozlova, 1962). The discovery of eudidymite at Seal Lake, Labrador was mentioned briefly in a recent paper by Nickel & Charette (1962).

The geology of the Seal Lake area has been described by Evans & Dujardin (1961) and Heinrich & Deane (1962). According to them, the host rock is a soda-rich paragneiss associated with volcanics and alkaline syenite. The principal minerals in the paragneiss are albite and arfvedsonite. Accessory minerals found to date include aegerine-augite, quartz, barylite, pyrochlore, neptunite, schizolite, sphalerite, galena, apatite, eudidymite, and a new mineral that appears to be the niobium analogue of astrophyllite (a paper on this last mineral is in progress). A number of other accessory minerals have not yet been identified, and work on these is continuing.

The Seal Lake eudidymite was discovered in diamond-drill core by Mr. R. A. Dujardin, geologist with Rio Tinto Canadian Exploration Limited, and was identified as such by the author. The mineral was subsequently found in other samples from the deposit.

## General Description

Eudidymite in macroscopically visible amounts has been observed in only a few samples, where it forms relatively coarse-grained segregations up to about an inch in diameter. In these segregations it has a rather foliated appearance due to the micaceous cleavage characteristic of the mineral, and to the sub-parallel arrangement of the individual grains. The largest cleavage surfaces observed were about 5 mm in diameter.

The eudidymite in other samples from the Seal Lake deposit appears to occur chiefly as disseminated grains. In these samples it could not be recognized either in hand samples or in thin-sections because of its similarity to albite, one of the dominant minerals in the rock. However, it was identified in immersion mounts made from heavy-liquid separates of the samples.

## Physical and Optical Properties

The Seal Lake eudidymite is white in the hand sample, and colourless in thin section in transmitted light. The refractive indices, measured on oriented cleavage fragments using calibrated refractive index liquids and sodium light are as follows: $\alpha = 1.544$, $\beta = 1.545$, $\gamma = 1.549$. $2V$, measured on the universal stage, is $+23°$. The extinction angle $Z \wedge c$ is 54°.

The mineral has perfect, almost micaceous, cleavage parallel to (001), and exhibits twinning parallel to this plane. The specific gravity, as determined by the heavy-liquid suspension method, is 2.578. This is in fairly good agreement with the calculated specific gravity of 2.595.

The refractive indices and birefringence of eudidymite are similar to those of albite. Consequently, it is very difficult to distinguish the two minerals, both in hand sample and in thin-sections. They can, however, be discriminated in immersion mounts with suitable refractive index liquids, particularly if phase contrast is used.

## Chemical Composition

1.6 grams of relatively pure eudidymite were obtained from one of the coarse-grained segregations by crushing a portion of the sample and subjecting it to repeated heavy-liquid separations. The resulting eudidymite concentrate was chemically analysed. The results of the analysis (Table 1) show that, except for the presence of $K_2O$, the composition of this eudidymite is very close to the theoretical eudidymite composition, also given in Table 1. The Langesundfjord eudidymite deviates from the theoretical

TABLE 1. CHEMICAL COMPOSITION OF EUDIDYMITE

| | Seal Lake, Labrador* (This paper) | Langesundfjord, Norway** (Nordenskiöld, 1887) | Theoretical composition ($NaBeSi_3O_7OH$) |
|---|---|---|---|
| $Na_2O$ | 12.20% | 12.45% | 12.64% |
| $K_2O$ | 0.39 | — | — |
| BeO | 10.15 | 10.89 | 10.20 |
| $SiO_2$ | 73.56 | 72.65 | 73.49 |
| $H_2O$ | 3.62 | 3.81 | 3.67 |
| Totals | 99.92 | 99.80 | 100.00 |

*ANALYSTS: D. J. Charette and Miss E. M. Penner, Analytical Chemistry Subdivision.
**AVERAGE of two analyses.

composition and from the Seal Lake analysis by its appreciably higher BeO and lower $SiO_2$ contents.

## *X*-RAY DIFFRACTION ANALYSIS

The *x*-ray powder diffraction data for the Seal Lake and Langesundfjord eudidymites are shown in Table 2. The powder data for the latter are in general similar to those published elsewhere for Langesundfjord eudidymite (Christophe-Michel-Lévy, 1961; Kozlova, 1962); the differences that do exist are relatively minor and are probably due to differences in measuring technique. The data given here were obtained from careful measurement of 114.6 mm Debye-Scherrer film, corrected for shrinkage.

A line-by-line comparison of the powder diffraction data in Table 2 shows that, with few exceptions, the *d*-values for the Seal Lake mineral

TABLE 2. EUDIDYMITE *X*-RAY POWDER DIFFRACTION DATA

| Line No. | Langesundfjord, Norway | | Seal Lake, Newfoundland | | | |
|---|---|---|---|---|---|---|
| | *I* (est.) | *d* (Å) | *I* (est.) | *d* (Å) | *hkl* | *d*(calc.) |
| 1 | 2 | 6.76 | 2 | 6.77 | 002 | 6.79 |
| 2 | 6 | 6.35 | 7 | 6.35 | 110 | 6.32 |
| 3 | 2 | 6.10 | 3 | 6.09 | 200 | 6.10 |
| 4 | | — | 1 | 5.98 | $\bar{1}11$ | 6.01 |
| 5 | 1 | 5.48 | 2 | 5.47 | 111 | 5.47 |
| 6 | | — | 1 | 5.18 | $\bar{2}02$ | 5.19 |
| 7 | 2 | 4.95 | 2 | 4.94 | $\bar{1}12$ | 4.93 |
| 8 | 2 | 4.35 | 3 | 4.37 | 112 | 4.36 |
| 9 | 3 | 3.928 | 3 | 3.914 | $\bar{1}13$ | 3.912 |
| 10 | 5 | 3.687 | 3 | 3.684 | 020 | 3.686 |
| 11 | | — | 2 | 3.640 | $\bar{3}11$ | 3.637 |
| 12 | | — | 1 | 3.565 | {310<br>{021 | 3.562<br>3.557 |
| 13 | 4 | 3.487 | 4 | 3.483 | 113 | 3.480 |
| 14 | 8 | 3.398 | 9 | 3.394 | 004 | 3.393 |
| 15 | 1 | 3.324 | 1 | 3.318 | $\bar{2}04$ | 3.320 |

TABLE 2 (*cont'd*)

| Line No. | Langesundfjord, Norway | | Seal Lake, Newfoundland | | *hkl* *hkl* | *d* (calc.) |
|---|---|---|---|---|---|---|
| | *I* (est.) | *d* (Å) | *I* (est.) | *d* (Å) | | |
| 16 | 2 | 3.234 | 2 | 3.243 | 022 | 3.239 |
| 17 | 10 | 3.163 | 10 | 3.160 | $\bar{2}21$<br>220<br>$\bar{1}14$ | 3.160<br>3.155<br>3.155 |
| 18 | 8 | 3.074 | 8 | 3.066 | $\bar{4}02$<br>400 | 3.070<br>3.052 |
| 19 | 6 | 2.999 | 6 | 3.001 | $\bar{2}22$<br>221 | 3.006<br>2.993 |
| 20 | 1 | 2.928 | 1 | 2.915 | 312 | 2.914 |
| 21 | 6 | 2.848 | 6 | 2.849 | 023<br>114 | 2.856<br>2.846 |
| 22 | 2 | 2.754 | 2 | 2.747 | $\bar{2}23$<br>222 | 2.752<br>2.735 |
| 23 | 1 | 2.715 | 1 | 2.706 | 204 | 2.705 |
| 24 | 3 | 2.603 | 3 | 2.598 | $\bar{4}04$ | 2.597 |
| 25 | 2 | 2.560 | 2 | 2.562 | 402 | 2.564 |
| 26 | 3 | 2.501 | 3 | 2.495 | 024 | 2.496 |
| 27 | 2 | 2.456 | 2 | 2.452 | $\bar{2}24$<br>223 | 2.467<br>2.450 |
| 28 | 2 | 2.416 | 1 | 2.418 | 130 | 2.409 |
| 29 | 2 | 2.396 | 2 | 2.393 | $\bar{1}31$<br>115 | 2.391<br>2.389 |
| 30 | 1 | 2.365 | 2 | 2.361 | $\bar{4}22$ | 2.359 |
| 31 | | — | 1 | 2.307 | $\bar{2}06$<br>$\bar{1}32$ | 2.308<br>2.306 |
| 32 | 2 | 2.263 | 2 | 2.262 | 006 | 2.262 |
| 33 | | — | 1 | 2.235 | 132 | 2.237 |
| 34 | 1 | 2.221 | 1 | 2.216 | $\bar{1}16$ | 2.218 |
| 35 | 2 | 2.183 | 2 | 2.186 | 025<br>224 | 2.186<br>2.181 |
| 36 | | — | 1 | 2.156 | $\bar{1}33$<br>$\bar{5}14$ | 2.169<br>2.154 |
| 37 | 2 | 2.125 | 2 | 2.123 | $\bar{4}24$<br>$\bar{3}16$<br>$\bar{3}31$ | 2.123<br>2.120<br>2.118 |
| 38 | | — | 1 | 2.084 | 133<br>$\bar{3}32$ | 2.086<br>2.083 |
| 39 | 2 | 2.056 | 2 | 2.053 | 116<br>404<br>331 | 2.051<br>2.040<br>2.041 |
| 40 | 5 | 2.014 | 5 | 2.011 | $\bar{1}34$ | 2.009 |

The data were obtained from fibre-mounted samples irradiated with iron-filtered cobalt radiation ($\lambda$ = 1.78890 Å); camera diameter 114.6 mm. Intensities were estimated visually.

are smaller than those of the corresponding lines in the Langesundfjord mineral. This indicates that the Seal Lake eudidymite has a smaller unit cell. Its unit-cell parameters, calculated from the powder data by a least-squares procedure, are $a$ = 12.568 Å, $b$ = 7.371 Å, $c$ = 13.976 Å, and $\beta$ = 103°47′. A comparison of these values with those of the Langesundfjord eudidymite given by Ito (1947), and shown in Table 3, shows that the $a$ and $c$ values of the Seal Lake eudidymite are appreciably smaller.

## Discussion

The physical and optical properties of the eudidymite from Seal Lake exhibit small but distinct differences from those of the Langesundfjord mineral (Table 3).

Table 3. Comparison of the Physical and Optical Properties of Eudidymite from Seal Lake and Langesundfjord

| | Seal Lake, Labrador (This paper) | Langesundfjord, Norway* |
|---|---|---|
| Refractive indices | | |
| $\alpha$ | 1.544 | 1.545 |
| $\beta$ | 1.545 | 1.546 |
| $\gamma$ | 1.549 | 1.551 |
| Birefringence ($\gamma-\alpha$) | 0.005 | 0.006 |
| $2V$ (+) | 23° | 30° |
| Extinction angle ($Z \wedge c$) | 54° | 58.5 |
| Specific Gravity | 2.578 | 2.553 |
| Unit-cell parameters | | |
| $a$ (Å) | 12.568 | 12.62 |
| $b$ (Å) | 7.371 | 7.37 |
| $c$ (Å) | 13.976 | 13.99 |
| $\beta$ | 103°47′ | 103°43′ |

*Optical data and specific gravity from Brögger (1890); crystallographic data from Ito (1947).

The chief compositional differences between the two minerals are in their BeO and $SiO_2$ contents. In the Seal Lake eudidymite these constituents are quite close to the theoretical values, but in the Langesundfjord mineral, the BeO content is appreciably greater, and the $SiO_2$ content appreciably less than the theoretical values. This suggests that some of the silicon has been replaced by beryllium in the Langesundfjord eudidymite.

Because of the similarity of their ionic radii, substitution of silicon by beryllium is quite common in some silicates, especially in micas and vesuvianite (Beus, 1956). Because beryllium has a lower valency than silicon, the resulting charge imbalance must be corrected. The most common mechanism in silicates appears to be replacement of divalent oxygen by monovalent fluorine or hydroxyl. Since no fluorine has been reported in the eudidymite analyses, it may be assumed that the charge imbalance has been corrected by the substitution of hydroxyl for some of the oxygen. Recalculation of the three eudidymite analyses available shows that both samples of the Langesundfjord eudidymite contain excess Be and OH and are deficient in Si and O, as expected (Table 4).

This substitution would explain the observed differences in physical properties between the Seal Lake and Langesundfjord minerals. Sub-

TABLE 4. ATOMIC PROPORTIONS IN EUDIDYMITE

| | Seal Lake, Labrador | Langesundfjord, Norway 1 | Langesundfjord, Norway 2 | Theoretical |
|---|---|---|---|---|
| Na | 0.97 | 1.00 | 0.97 | 1.00 |
| K | 0.02 | — | — | — |
| Be | 1.00 | 1.09 | 1.04 | 1.00 |
| Si | 3.01 | 2.93 | 2.98 | 3.00 |
| OH | 0.99 | 1.04 | 1.03 | 1.00 |
| O | 7.01 | 6.94 | 6.98 | 7.00 |
| | 13.00 | 13.00 | 13.00 | 13.00 |

stitution of hydroxyl for oxygen would be expected to create an expansion of the unit cell and an increase in refractive indices, both of which are characteristic of the Langesundfjord eudidymite. The specific gravity would be increased slightly by substitution of oxygen by hydroxyl, but this would be more than balanced by the larger decrease due to substitution of silicon by beryllium and by the effect of the larger unit cell. This is also in accordance with the observed fact that the specific gravity of the Langesundfjord mineral is substantially lower than that of the Seal Lake eudidymite.

In summary, it may be concluded that partial substitution of silicon and oxygen by beryllium and hydroxyl does occur in eudidymite, and that this substitution accounts for observed variations in physical and optical properties.

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