# CANCRINITE FROM BLUE MOUNTAIN, ONTARIO

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During the summer of 1947 while visiting the quarries of the American Nepheline Corporation at Blue Mountain in Methuen township, Ontario, Phoenix collected several specimens of fine, amber-yellow cancrinite. He subsequently analyzed selected material from the specimens on his return to Toronto. A portion was handed to Nuffield for further study. Professor M. A. Peacock and Mr. E. G. Robinson kindly undertook to measure the indices of refraction in Na light. Although chemical analyses of cancrinite with optical data are fairly plentiful in the literature, only one analysis is accompanied by cell dimensions. Therefore it was felt worthwhile to record the data collected during the study. This paper also discusses the chemical constitution of cancrinite and certain relationships between composition and optical properties.

The Blue Mountain cancrinite yielded a fragment showing the excellent hexagonal prismatic cleavage, permitting good rotation and Weissenberg films about the *c*-axis; these gave the cell dimensions[3] compared below with previous determinations:

| *a* | *c* | |
|---|---|---|
| 12.73 | 5.10 | Monte Somma, Vesuvius (Zambonini & Ferrari, 1930) |
| 12.60 | 5.18 | Miask, Urals (Gossner & Mussgnug, 1930) |
| 12.72 | 5.18 | Dôdô, Korea (Kôzu & Takané, 1933) |
| 12.60 | 5.12 kX | Blue Mountain, Methuen, Ontario (E. W. N.) |

Two determinations of the specific gravity were made: 2.420 (R. P., on a piece weighing several grams), 2.423 (E. W. N., on a fragment (16 mg.) using the Berman microbalance).

Bragg (1937, p. 272), Berman (1937, pp. 365, 369), and others have concluded that cancrinite has a 3-dimensional framework of (Si,Al)-$O_4$ tetrahedra (silica type) with the ideal composition $(Si_6Al_6O_{24})^{6-}$. Berman pictures this structural type as having large open spaces, some of which are occupied by $CO_3$ and $SO_4$ groups. Large cations enter the structure and neutralize the charge on these groups and on the framework. Specific gravities are characteristically low due to the open nature of the atomic structure. This view of cancrinite is supported by the data presented in Table 1 which gives the new analysis and cell contents calculated from the analysis, the measured specific gravity and the mass factor 1.650. Si and Al are both near 6, oxygen is near 24.

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[3] Using $\lambda$ Cu$K\alpha_1 = 1.5374$ kX.

When cancrinite analyses are compared they are usually recalculated to give atomic proportions on a basis of $Si+Al=12$ (Berman, 1937; Stewart, 1941). This almost invariably results in oxygen less than 24. It appears unlikely that water in the form of (OH) is substituting for oxygen. Zambonini & Ferrari (1930) found that the water is driven off at 375° C. without affecting the optical properties and concluded that it is not essential. Oxygen atoms are usually the largest in a silicate structure and they play an important part in determining the size and shape of the skeleton. It follows that the number of these atoms in a silicate formula is more apt to be constant than that of any other element. For this reason we have recalculated selected analyses of cancrinite for which optical data are available on a basis of $O=24$ (Table 2). In all the analyses except 3 the sum $Si+Al$ is now greater than 12. This shows that in cancrinite, as in other silicates, some Al substitutes for the cations.

TABLE 1. ANALYSIS AND CELL CONTENTS OF CANCRINITE,
BLUE MOUNTAIN, ONTARIO
Analyst: R. Phoenix

| | | | |
|---|---|---|---|
| $SiO_2$ | 33.98 | Si | 5.83 |
| $Al_2O_3$ | 29.11 | Al | 5.88 |
| $Na_2O$ | 18.69 | Na | 6.22 |
| $K_2O$ | 0.64 | K | 0.14 |
| CaO | 4.80 | Ca | 0.88 |
| $CO_2$ | 7.00 | $CO_3$ | 1.64 |
| $SO_3$ | 1.37 | $SO_4$ | 0.18 |
| Cl | 0.42 | Cl | 0.12 |
| $H_2O+$ | 4.34 | $H_2O+$ | 2.48 |
| $H_2O-$ | 0.23 | O | 22.66 |
| O for $Cl_2$ | −0.10 | | |
| | 100.48[4] | | |

[4] Incl. FeO none, MgO none.

Berman (1937) noted a tendency in the "normal" (i.e. nonsulphatic) cancrinites for Ca to increase as $Na+K$ decreases. This is seen to be true also for sulphatic cancrinite, indicating isomorphous substitution of Ca for $Na+K$. Berman also observed a tendency for $CO_3$ to increase with Ca. Similarly our table indicates an increase in $SO_4$, and consequent decrease in $CO_3$, with Na. It may be said that in general those natural cancrinites which are high in Ca are carbonic, while the cancrinites high in Na are sulphatic.

From the data in Table 2 the general chemical formula of cancrinite along with the maximum charges on the different groups of atoms may be written as $(Na,K,Ca,Al)^{10+}_{6-8}Si_6Al_6O^{6-}_{24}\cdot(SO_4,CO_3)^{4-}_{1-2}\cdot 1-5H_2O$. This is in agreement with the formula of Berman (1937, p. 356), except that our formula shows inclusion of some Al with the cations and a greater range of water-content. The table indicates that the relation Si = Al = 6 is nearly realized in all analyses; the charge on the framework is therefore always close to 6−. However, the $CO_3+SO_4$ content is usually less than 2 and may be as low as 1. Consequently the charge on these groups varies in different cancrinites and is characteristically less than 4−. This variation in negative charge together with considerable isomorphous substitution of Ca for Na results in a cation content which varies between 6 and 8. Therefore it may be assumed that the cancrinite structure practically always contains unfilled positions. This is borne out by the measured specific gravities of various cancrinites (Table 2). They are distinctly

TABLE 2. CANCRINITE: ATOMIC PROPORTIONS (O=24), OPTICAL PROPERTIES, AND SPECIFIC GRAVITIES

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Si | 6.28 | 5.94 | 5.97 | 6.17 | 5.99 | 5.94 | 6.25 | 6.21 |
| Al | 5.94 | 6.21 | 5.96 | 6.23 | 6.16 | 6.21 | 6.01 | 6.06 |
| Na | 3.38 | 5.27 | 5.97 | 6.59 | 6.38 | 6.26 | 5.37 | 5.40 |
| K | 0.28 | 0.11 | 0.04 | 0.15 | 0.33 | 0.28 | 0.94 | 1.12 |
| Ca | 2.22 | 1.63 | 1.48 | 0.93 | 0.80 | 0.71 | 0.28 | 0.24 |
| $CO_3$ | 1.50 | 1.64 | 1.36 | 1.74 | 0.77 | 0.44 | 0.24 | 0.22 |
| $SO_4$ | 0.03 | 0.01 | 0.01 | 0.19 | 0.62 | 0.76 | 0.77 | 0.84 |
| Cl | 0.02 | — | 0.01 | 0.13 | — | — | — | — |
| O | 24.00 | 24.00 | 24.00 | 24.00 | 24.00 | 24.00 | 24.00 | 24.00 |
| $H_2O$ | 3.78 | 2.71 | 1.54 | 2.63 | 2.51 | 1.31 | 4.50 | 4.17 |
| (Si, Al) | 12.00 | 12.00 | 11.93 | 12.00 | 12.00 | 12.00 | 12.00 | 12.00 |
| (Na, K, Ca, Al) | 6.10 | 7.16 | 7.49 | 8.07 | 7.66 | 7.40 | 6.85 | 7.03 |
| ($CO_3$, $SO_4$, Cl) | 1.55 | 1.65 | 1.38 | 2.06 | 1.39 | 1.20 | 1.01 | 1.06 |
| $\omega$ | 1.528 | 1.524 | 1.5238 | 1.515 | 1.509 | 1.502 | 1.492–1.493 | |
| $\epsilon$ | 1.503 | 1.501 | 1.5015 | 1.496 | 1.500 | 1.497 | | |
| $\omega-\epsilon$ | 0.025 | 0.023 | 0.0223 | 0.019 | 0.009 | 0.005 | 0.0007 | |
| G | 2.476 | 2.51 | 2.44 | 2.422 | 2.443 | 2.423 | 2.35 | |

1. Bancroft, Ont.; anal. Meen (1938). 2. Iron Hill, Gunnison Co., Colorado; anal. Larsen and Foshag (1926). Incl. Mg 0.10; Ti 0.01; Mn, Cl trace. 3. Dôdô, Korea; anal Kôzu (1931). Incl. Mg 0.01; Fe''', P trace. 4. Blue Mountain, Methuen, Ontario; anal. Phoenix (this paper). Incl. Fe'', Mg none. Refractive indices by M. A. Peacock and E. G. Robinson. 5. Beaver Creek, Colorado; anal. Steiger (in Larsen and Steiger, 1916). Incl. Sr 0.01; Ti 0.01. 6. Allt á Mhuillin, Loch Borolan, Assynt, Scotland; anal. Stewart (1941). Incl. Sr 0.03. 7. Ilmen Mts., Ural; anal. Morachevsky (in Zavaritzsky, 1929). Incl. Mg 0.03; Fe''' 0.03. 8. Ilmen Mts., Ural; anal. Morachevsky (in Zavaritzsky, 1929). Incl. Mg 0.03; Fe''' 0.01.

lower than the value 2.59, calculated for $Na_6Ca_2 \cdot Al_6Si_6O_{24} \cdot 2CO_3 \cdot 3H_2O$, which presumably contains the maximum number of atoms. The available data do not point to any connection between the vacant positions and the water content.

Stewart (1941) noted that the optical properties are affected by variation in composition. He pointed out that with increasing $SO_4$, $\omega$ falls rapidly, $\epsilon$ less so, resulting in a decrease in birefringence. The analyses in Table 2 have been arranged in order of decreasing birefringence caused by a decrease in $\omega$ and somewhat irregular decrease in $\epsilon$. Although this is the order of increasing $SO_4$ in the sulphatic cancrinites (4–8), it is also the order of decreasing Ca, and decreasing Ca/(Na+K) for all the analyses. The indices of refraction and birefringence are characteristically higher in the calcic members of Ca-Na series such as the plagioclases, the scapolites, and some of the zeolites.

## REFERENCES

BERMAN, H. (1937): Constitution and classification of the natural silicates—*Am. Mineral.*, **22,** 342–408.

BRAGG, W. L. (1937): Atomic structure of minerals—Ithaca, New York.

GOSSNER, B. AND MUSSGNUG, F. (1930): Über Davyn und seine Beziehungen zu Hauyn und Cancrinit—*Zeits. Krist.*, **73,** 52–60.

KÔZU, S. (1931): Preliminary note on studies of cancrinite from Korea—*J. Jap. Assoc. Min. Petr. Econ. Geol.*, **5,** 1–14 [*Min. Abs.*, **5**–48].

—— AND TAKANÉ, K. (1933): Crystal structure of cancrinite from Dôdô, Korea, I—*Proc. Imp. Acad. Japan*, **9,** 56–59.

LARSEN, E. S. AND STEIGER, G. (1916): Sulphatic cancrinite from Colorado—*Am. J. Sci.*, **42,** 332–334.

—— AND FOSHAG, W. F. (1926): Cancrinite as a high temperature hydrothermal mineral from Colorado—*Am. Mineral.*, **11,** 300–303.

MEEN, V. B. (1938): An unusual cancrinite—*Univ. Toronto Studies*, Geol. Ser., **41,** 35–38.

STEWART, F. H. (1941): On sulphatic cancrinite and analcime (eudnophite) from Loch Borolan, Assynt—*Min. Mag.*, **26,** 1–8.

ZAMBONINI, F. AND FERRARI, A. (1930): Sulla identitá di struttura cristallina della cancrinite del Monte Somma con quella di Mias—*Atti R. Ac. Lincei, Cl. Sci. fis. mat. nat.*, **11,** 782–788 [*Min. Abs.*, **4**–355].

ZAVARITZKY, A. N. (1929): Sulphatic cancrinite from the Ilmen Mountains (South Ural)—*Mém. Soc. Russe Min.*, **38,** 201–207 [*Min. Abs.*, **4**–379].