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## OPTICAL ANOMALIES IN ARFVEDSONITE FROM GREENLAND

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Many alkali amphiboles fail to show complete extinction on (010) between crossed nicols, not even in monochromatic light. The phenomenon was observed by Eskola and Sahlstein (1930) on three amphiboles of the arfvedsonite-riebeckite series, on two alkali amphiboles later called eckermannite by Adamson (1944), on one specimen of hastingsite and one of taramite. The incomplete extinction was found only in sections roughly parallel with (010). On (100), striations parallel with the trace of the *c*-axis were noted.

At that time, no closer experimental study of the phenomenon was made. It was only assumed that the amphiboles, originally crystallized as a homogeneous phase, have later been subjected to exsolution and are now perthitic. The lath-shaped strips are arranged in such a way that the *c*-axis and the (010) plane are common for the exsolved amphibole components.

Later, the incomplete extinction of certain alkali amphiboles, particularly of those belonging to the arfvedsonite-riebeckite series, have been mentioned by a number of Japanese authors (Sato, 1936; Iwao, 1939; Hori, 1942; Inoue, 1950; Yagi, 1953). The phenomenon seems to be very common in alkali-rich amphiboles.

To explain the optical anomalies pointed out above, a specimen of arfvedsonite from Kangerdluarsuq, Greenland (this Institute Collection No. 3436), was studied with more modern equipment. The incomplete extinction on (010) and the striated structure on (100) are very clearly seen on this mineral. Chemical analysis and optical properties of arfvedsonite No. 3436 are given in Table 1.

The material for the chemical analysis was purified by centrifuging in Clerici's solution. The purity of the final powder was tested under the microscope. The optical properties were determined in the usual manner. For determining the optical orientation and for quantitative measurement of the pleochroism and of the degree of non-extinction, thin sections were cut parallel with (010) and (100). On the section (010) it was found that the direction of maximum absorption (=optical $\alpha$) is parallel with

TABLE 1. CHEMICAL COMPOSITION AND OPTICAL PROPERTIES OF ARFVEDSONITE No. 3436 FROM KANGERDLUARSUQ, GREENLAND

| | | | | |
|---|---|---|---|---|
| $SiO_2$ | 46.61% | $Na_2O$ | 6.58% | $\alpha=1.696$ ±0.003 |
| $Al_2O_3$ | 4.02 | $K_2O$ | 2.89 | $\beta=1.700$ ±0.003 |
| $Fe_2O_3$ | 9.92 | $TiO_2$ | 0.48 | $\gamma=1.705$ ±0.003 |
| FeO | 25.79 | $H_2O^+$ | 1.24 | $c\wedge\alpha=0°$ |
| MnO | 0.00 | $H_2O^-$ | 0.00 | $b\parallel\gamma$ |
| MgO | 0.25 | Total | 99.84 | Absorption: |
| CaO | 2.06 | | | $\alpha>\gamma>\beta$ |

the trace of the crystallographic *c*-axis. This is unusual for an arfvedsonite. The relative amounts of transmittance of light vibrating parallel with the three indicatrix axes are given in Table 2. The transmittance of $\beta$ at 700 m$\mu$ was arbitrarily taken as 10.00 and the values of the table were reduced to correspond to that figure. The measurements were carried out with the Leitz microscope photometer and the Leitz monochromator.

TABLE 2. PLEOCHROISM OF ARFVEDSONITE No. 3436, KANGERDLUARSUQ, GREENLAND. RELATIVE AMOUNTS OF TRANSMITTANCE OF LIGHT VIBRATING PARALLEL WITH THE THREE INDICATRIX AXES. MEASURED WITH THE LEITZ MICROSCOPE PHOTOMETER

| Wave length m$\mu$ | Relative transmittance of light vibrating parallel with | | |
|---|---|---|---|
| | $\alpha(=c)$ | $\beta$ | $\gamma(=b)$ |
| 450 | 0.43 | 3.30 | 0.71 |
| 500 | 0.83 | 5.98 | 1.06 |
| 550 | 0.55 | 6.34 | 0.75 |
| 600 | 0.43 | 7.40 | 0.72 |
| 650 | 0.36 | 9.25 | 0.80 |
| 700 | 0.27 | 10.00 | 0.82 |

Table 3 gives the degree of non-extinction for light vibrating parallel with optical $\alpha$ (=crystallographic *c*-axis) on section (010). The amounts of transmittance given in the second column of the table (without analyzer) were taken as 100 and the transmittance values in the third column (with analyzer) were reduced correspondingly. The fourth column indicates the minimum relative amounts of transmittance measurable with the apparatus. As is seen from the table, the analyzer reduces but slightly the intensity of the transmitted light. At 700 m$\mu$ the intensity of the transmitted light is not influenced by the analyzer at all. A complete extinction is reached only if the analyzer is turned parallel with the polarizer.

TABLE 3. ARFVEDSONITE NO. 3436, KANGERDLUARSUQ, GREENLAND. RELATIVE TRANSMITTANCE OF LIGHT VIBRATING$\|\alpha(=c$-AXIS). SECTION (010). MEASURED WITH THE LEITZ MICROSCOPE PHOTOMETER

| Wave length mμ | Relative transmittance measured on section (010) for vibration $\|\alpha(=c$-axis) | | Minimum transmittance still measurable with the photometer |
|---|---|---|---|
| | Without analyzer | With analyzer (nicols crossed) | |
| 450 | 100 | 71 | 10 |
| 500 | 100 | 91 | 5 |
| 550 | 100 | 96 | 7 |
| 600 | 100 | 96 | 10 |
| 650 | 100 | 98 | 13 |
| 700 | 100 | 100 | 16 |

The optical anomalies described above are apparently caused by some kind of mosaic structure. To reveal the nature of this mosaic structure, a rotation photograph and a zero-layer Weissenberg photograph were taken of the arfvedsonite, using cobalt radiation with iron filter. The crystal was rotated or oscillated around the crystallographic $c$-axis. The rotation photograph shows sharp layer lines indicating that the entire crystal is homogeneous with respect to its $c$-axis. In other words, if there are domains of different orientation in the crystal, these domains must have the $c$-axis in common. This will hold true within the accuracy attainable by a rotation photograph. On the other hand, the reflections with lower $\xi$-values on the Weissenberg photograph (that do not normally show separate CoK$\alpha_1$ and CoK$\alpha_2$ spots) are very clearly doubled throughout the film. The polar coordinates $\xi$ and $\phi$ were measured for each reflection and the $hk0$ reciprocal lattice plane was constructed. The doubled $hk0$ pattern is regular and shows no rotation of different domains around the $c$-axis.

The $x$-ray data reported above seem to indicate that the arfvedsonite No. 3436 represents a perthitic intergrowth of two amphibole components with slightly differing unit cell dimensions. To test this interpretation, fragments of the same crystal were heated for one hour at 700° C. Microscopic investigation of the heated material revealed the fact that the optical anomalies had disappeared and sections parallel with (010) showed sharp and complete extinction. Of the heated material rotation photograph and zero-layer Weissenberg photograph was taken in the same way as of the unheated material. The Weissenberg photograph of the heated material showed no doubling of the reflections. The crystal had become homogeneous.

It is concluded that an amphibole of the arfevdsonite composition is not stable at low temperatures but will become unmixed. The compositional range of the gap in alkali amphibole solid solutions is not known. The optical properties of the alkali amphiboles, particularly of the arfvedsonite-riebeckite series, must necessarily be influenced by the exsolution.

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# UNIT CELL AND SPACE GROUP OF BARYLITE

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The occurrence of barylite, $Be_2BaSi_2O_7$, has been described by Palache and Bauer (1) and by Palache (2) from Franklin, N. J., and by Aminoff (3) from Långban, Sweden. Ygberg (4) made an $x$-ray examination of the barylite from Långban, by the rotation, Laue and powder methods. Aminoff, from morphological investigation, found that barylite belonged to the orthorhombic holohedral class ($D_{2h}$—$mmm$). The $x$-ray study by Ygberg reduced the space group to two possible choices, $D_{2h}^5$—$Pmma$ and $D_{2h}^{16}$—$Pnma$, of which he considered the latter to be the more plausible.

An analyzed sample of the barylite from Franklin described by Palache and Bauer (1) was examined using Cu radiation and the Weissenberg method. The lattice type proved to be primitive orthorhombic, and the following extinction criteria were recognized: $hk0$ missing when $h$ is odd; $0kl$ missing when $k+l$ is odd. These establish the space group as