AXIAL ANGLE DETERMINATIONS IN ORVILLE'S MICROCLINE–LOW ALBITE SOLID SOLUTION SERIES[1]

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Abstract

Axial angle measurements on samples of microcline-low albite solid solutions prepared by Orville indicate a linear or near linear relationship between axial angle and composition. Extinction positions were measured on a 4-axis universal stage with an accuracy of $\pm 3°$. The curve calculated from the data is $Y = -0.274X + 102.66$ where $Y = 2V$ and $X =$ mole percent Or. This study indicates that potassic feldspars with maximum triclinicity are optically negative and that the existence of iso-microcline (optically positive microcline) is highly unlikely.

Recently there has been much interest in the use of optical properties, particularly axial angle, in the determination of composition of alkali feldspars, $(K,Na)AlSi_3O_8$. Most studies have been directed toward feldspars of high structural state because these are the ones that have been synthesized. The suite of feldspars in the microcline-low albite series prepared by Orville (1967) presented an opportunity to tie optical measurements to data for well-documented highly-ordered alkali feldspar. I am indebted to my colleague, David B. Stewart of the U. S. Geological Survey, for suggesting this study and to Philip Orville of Yale University for supplying samples of his exchanged feldspars.

There have been recurring references in the literature to optically positive microcline (DuParc, 1904; Barth, 1933; Tsuboi, 1936; Anderson and Maclellan, 1937; Kazakov, 1956; and Emerson, 1964). It was hoped that an optical study of the Orville samples would contribute to the solution of this problem and be useful in correlating 2V with composition within the microcline-low albite series.

Unfortunately the samples proved very difficult to work with and the results only partially met the goals of the investigation. Nevertheless, it is felt worthwhile to publish them because the data (1) make the existence of optically positive (isomicrocline) microcline highly unlikely, (2) warn against the use of axial angle measurements for accurate compositional determinations in these feldspars, and (3) illustrate the problems of working with metastable feldspars.

Seven samples of the microcline-low albite series were studied, including the two end members and five intermediate members. An estimated 200 or more grains, 100–200 mesh fraction, of each sample were mounted in Canada balsam beneath a cover slip. The axial angles were measured on a Leitz 4-axis universal stage using white light and extinction posi-

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tions. The major difficulty was finding enough grains in each mount on which $2V$ could be measured. Very fine grid twinning is almost universally present. Most of the twin lamellae are between 0.002 and 0.01 mm thick. Those grains on which the fine grid twinning is present are unsuitable for $2V$ determinations because of the difficulty in recognizing which lamellae were at extinction for various positions of the universal stage. Usually only 3 or 4 untwinned or coarsely twinned grains could be found in each mount and it was these grains that were measured.

Orville (1967) pointed out that microcline starting material from the Hugo pegmatite, Black Hills, South Dakota contained as inclusions about 7 percent plagioclase, and that twin lamellae in the plagioclase inclusions are considerably coarser than twin lamellae in the microcline host. The difference in character of twinning should persist through the exchange and homogenization procedure, and appear in the samples studied optically. Probably most if not all of the axial angle measurements were made on grains that were originally plagioclase. After exchange and homogenization, to the extent that equilibrium obtains, compositions of the inclusions and matrix should be identical.

The initial structural state of the plagioclase inclusions possibly differs from that of the microcline host. If so, correlation of the axial angle measurements with the unit-cell parameters determined by Orville would not be valid. Differences in ordering within an exchanged and homogenized sample would be difficult to detect by the X-ray powder methods, because that method best measures average properties of bulk samples. However, Orville also determined the unit-cell parameters of albite collected from the Hugo pegmatite within five feet of the microcline sample used as his starting material. Unit-cell parameters of the Hugo albite and of K-exchanged Hugo albite compare favorably with those of the end members of the Hugo microcline exchange series (Orville, 1967, Table 2). Thus, to a first approximation, the structural states of the microcline host and plagioclase inclusions should be the same.

Most of the axial angles were of necessity determined by measuring V and doubling, which also doubles the uncertainty of measurement. Most of the values represent one determination on each grain, with an accuracy of $\pm 3°$.

The measurements are presented in Table 1 and are also plotted on Figure 1. The variation within several of the samples is greater than the estimated uncertainty of measurement. Two lines of evidence suggest that the large variations within some samples are real and not just the result of poor measurements. First, in sample no. 57–63 two grains were recognized on two different days and the $2V$'s of both grains were measured on both days. The results were identical (86° for one grain on both

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TABLE 1. AXIAL ANGLE MEASUREMENTS ON THE ORVILLE MICROCLINE-LOW
ALBITE SOLID SOLUTION SERIES

Orville sample No.	Composition, mole percent Or	$2V$ (of different grains)
128–62	0.9	100, 100, 101[1]
157–63	19.7	98, 102, 102
51–63	39.0	90, 90, 92*, 96
57–63	58.7	81, 86, 86, 100[2]
156–63	78.9	77, 81*, 84
56–63	89.2	78, 78*, 83
131–62	99.6	68, 73, 74, 78, 82

[1] Direct measurement of $2V$ between both optic axes.
[2] Rejected (see text).

days and 100° for the other grain on both days). Second, the error of
closure for the principal sections of the indicatrix plotted on a stereo-
graphic net is small, $\pm 2°$ for most measurements. The most reasonable
explanation for the larger spreads of axial angle within each sample is
that the starting materials reacted incompletely during homogenization.

Using the observed values of axial angle, and the compositional data
given by Orville (1967), a straight line has been calculated using the least
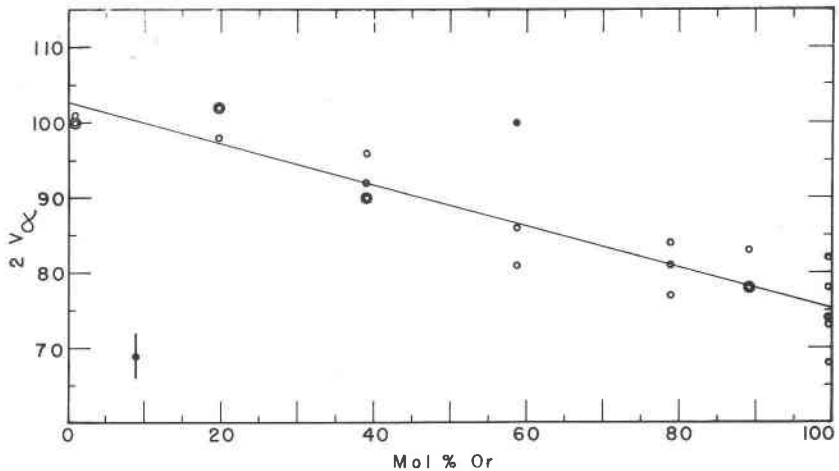

FIG. 1. Optic axial angle plotted against chemical composition for the microcline-low
albite solid solution series. Open circles represent single observations on different grains;
concentric circles represent identical observations on different grains. The value of the solid
circle was rejected in calculating the curve (see text). The length of the line in the lower left
corner of the diagram represents the estimated uncertainty of the measurements.

squares refinement computer program of the U. S. Geological Survey (Fig. 1). The resulting curve is

$$Y = -0.274\ X + 102.66$$

where $Y = 2V$ and $X =$ composition in mole percent Or. For sample no. 57–63, $2V = 100°$ was rejected before the calculation, because it was more than 3 standard deviations from the calculated curve at this composition, and the measured grain clearly did not reach equilibrium during homogenization.

Although the data are rather meager, the conclusion that there is a linear or nearly linear relationship between axial angle and composition in the microcline-low albite solid solution series is inescapable. The calculated curve indicates $2V = 90°$ for a feldspar with the composition $Or_{46.2}$. Potassic feldspars with maximum triclinicity are thus optically negative.

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