PETROFABRIC RELATIONS OF NEPHELINE AND ALBITE IN LITCHFIELDITE FROM BLUE MOUNTAIN, ONTARIO

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ABSTRACT

Petrofabric analysis of a specimen of litchfieldite from Blue Mountain, Ontario, shows: (1) Foliation and lineation expressed principally by elongate tabular albite crystals; (2) (010) of albite parallel to the foliation; (3) c_v of nepheline and albite approximately parallel to each other and to the lineation. This orientation is interpreted as the result of normal igneous crystallization; in the case of the earlier albite from flowing magma, in the case of the later nepheline from stagnant residual liquid.

INTRODUCTION

Although previous petrofabric studies of albite have been made (1) there is no published information concerning the orientation of nepheline. The abundance of the latter mineral in the Blue Mountain alkaline rocks recently studied by Keith (2) led to a search for material suitable for petrofabric analysis. In most specimens of such rocks there are too few grains of nepheline per thin section to make a statistical analysis practicable unless a number of successive parallel sections are prepared. Commonly the grains are highly altered and unsatisfactory for orientation work. Also, foliation and lineation may not be discernible and interpretation of the orientation is thus made hazardous. One of the Blue Mountain specimens met these difficulties successfully and was made available to me by Keith for petrofabric analysis. The data presented here are not in any way final, but it was thought advisable to present the existing information rather than withhold publication indefinitely during the search for more material.

MINERALOGY AND GEOLOGICAL RELATIONS OF THE LITCHFIELDITE

Litchfieldite is a medium-grained, leucocratic nepheline rock in which potash feldspar makes up less than one-half the total feldspar.[1] The average modal proportions of the three principal minerals in the Blue Mountain variety are: microcline 20%, nepheline 22%, albite 54%. The rock forms an irregular, oval stock one and one-half by three miles in its greatest surface dimensions, with a long narrow projection extending two and one-quarter miles from one end. It is intrusive into hornblende-biotite schist. Both invaded and invading rocks are of pre-Cambrian age.

[1] Such rocks are erroneously called nepheline syenite. The potash feldspar in true nepheline syenite amounts to more than one-half the total feldspar (2).

The long axis of the outcrop of the litchfieldite strikes about N30°E, parallel to the regional trend. Dips at the borders of the main stock are 60°–70° inward. Foliation is conspicuous only in places near the contacts. The poorly developed lineation, where observed, is approximately horizontal.

The litchfieldite is uniformly medium-textured. Albite is more coarsely crystallized than microcline and nepheline and occurs in unzoned, subhedral crystals. It has abundant albite twins and an anorthite content of less than 5%. Nepheline is interstitial to albite and microcline and in part follows their grain boundaries. In places it forms intergrowths with albite which are of replacement origin. All the minerals are clear and unaltered.

Petrofabric Analysis

The specimen selected for statistical analysis shows both lineation and foliation. These structural elements are largely due to the predominant albite, which occurs for the most part in inequant grains. These have a tabular habit which gives rise to a rude foliation, and in addition are elongate, producing a visible lineation. Two thin sections were studied, one perpendicular to the lineation, and one parallel to it, both being perpendicular to the foliation. Figures 1, 2, and 3 are collective diagrams oriented parallel to the lineation b, and show the results of measurements made on these sections. The foliation s, drawn as a great circle about 6° from the center of the figures, indicates that the section was not cut exactly perpendicular to s.

The most conspicuous orientation is shown in Fig. 1, where the poles to (010) planes of albite have an average position about perpendicular to the observed s-surface in the specimen. Figure 2 shows the orientation of the optic direction β in the same albite grains. The chief concentrations are at the margin of the diagram approximately 90° from the (010) pole maximum of Fig. 1. If s is taken as the average (010) plane, then for albite the two chief directions of β are as shown.[2] The crystallographic axis c_v then lies midway between the two β positions, or parallel to the lineation of the rock. There is sufficient concentration of β adjacent to the two ideal positions in Fig. 2 to justify a relatively fixed position for c_v. This means that the (010) albite planes are not only parallel, but that there is a tendency for parallelism of the c_v directions contained in them. In terms of the dimensional orientation associated with this crystallo-

[2] Triclinic crystals (such as the plagioclase series) have four possible positions of any optic direction in terms of a fixed crystallographic plane. However, the optic-crystallographic relations in albite are such that for petrofabric work two of these four possible positions may be neglected. (For details consult any work on optical mineralogy.)

graphic orientation, (010) is statistically parallel to the foliation, and c_v is parallel to the lineation. This orientation is one of the commoner ones previously determined for albite (1).

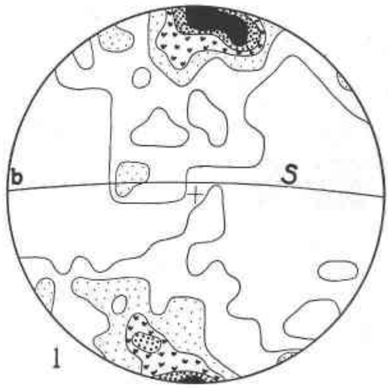

FIG. 1. Collective diagram of 110 poles to (010) of albite; *s*—foliation; *b*—lineation. Contours 9-7-5-3-1-0%.

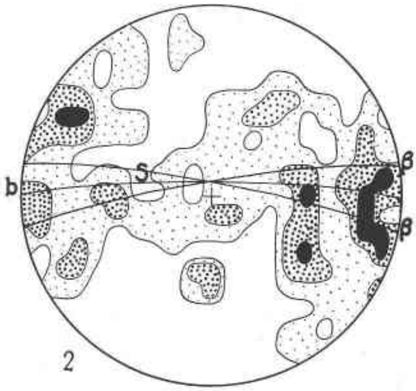

FIG. 2. Collective diagram of 110 β's of albite; *s* and *b* as in Fig. 1. The remaining two great circles show the orientation of the two significant β directions, assuming c_v is parallel to lineation *b*. Contours 5-3-1-0%.

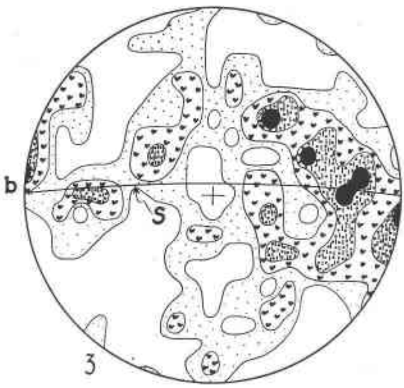

FIG. 3. Collective diagram of 254 vertical crystal axes c_v of nepheline; *s* and *b* as in Fig. 1. Contours 4-3-2-1-0%.

Figure 3 shows the orientation of the vertical crystal axes c_v of the nepheline interstitial to the albite and microcline. Although not very pronounced there is an indication that the axes prefer the *s*-surface in general and the lineation in particular as concentration areas. As with quartz, it is not possible by optic means to determine the precise orientation of the prism zone with respect to *s*.

The three diagrams indicate, in summary, that (010) of albite is parallel to the foliation and that c_v of both nepheline and albite tend to lie parallel to the lineation. In addition the dimensional orientation of albite is closely related to this crystallographic orientation, since the parallel tabular crystals form the foliation and the long dimensional axes c_v form the lineation.

Discussion of Orientation

As no systematic petrofabric study of the Blue Mountain intrusive was attempted, a lengthy discussion of the orientation just described would be futile. A few remarks can be made however without undue extrapolation of the facts. The prinicpal observation concerns the improbability that deformation played any part in producing the orientation. This is supported both by field and petrographic evidence (2). The crystallographic orientation of the albite and nepheline is not significant in this respect since nothing is known experimentally of the gliding elements of these minerals. The dimensional orientation of the albite is significant however and indicates that growth orientation resulting from normal igneous crystallization is probably the best hypothesis. Albite crystallized before nepheline and, with microcline (orientation undetermined), makes up almost 75% of the rock. The albite orientation is probably the result of magmatic flow, and the long axes of the tabular crystals may indicate the direction of flow. Details of the foliation and lineation in the litchfieldite are too meagre however to permit generalization about the magma movement on the evidence of the single specimen studied here.

The nepheline orientation is probably controlled by the pre-existing albite orientation. Since the greater part of the magma had already crystallized at the time of the nepheline precipitation, there would be no appreciable flow at this stage. The liquid from which the nepheline crystallized was thus essentially stagnant and the nepheline was not subjected to the orienting influence of flow. The tendency to parallelism of the vertical axes of nepheline and albite may therefore follow the law of minimum interfacial energy (3) used to explain parallel grouping of crystals and the orientation of inclusions in large single crystals. That is, the crystallizing nepheline seed-crystals tend to come to rest on the albite plates in that position which is most stable from the standpoint of interfacial energy. No study of oriented inclusions involving this particular pair of minerals has ever been made, but by analogy with other oriented inclusions some such mechanism may well explain the albite-nepheline relations in the Blue Mountain stock.

Acknowledgments

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Bibliography

1. Schmidt, W., Zur Regelung zweiachsiger Mineralien etc.: *Neues Jahr. Min.*, **57**, A, 203 (1928).
2. Keith, M. L., Petrology of the alkaline intrusive at Blue Mountain, Ontario: *Bull. Geol. Soc. Am.*, **50**, 1795 (1939).
3. Frondel, Clifford, Oriented inclusions in muscovite etc.: *Am. Mineral.*, **25**, 69 (1940).