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On the Anorthite Found in Lava Flow

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Abstract

A primitive anorthite lattice has been considered to be characteristic of pure and nearly pure (more than 93~95% *An*) anorthite occurring in metamorphic or plutonic rocks. But, anorthite occurring in certain lava flow, *An*-content of which is about 95%, is also primitive.

Introduction

The existence of low- and high-temperature modifications of albite was first observed optically by Spencer (1937). Tuttle and Bowen (1950) confirmed the two forms by means of an X-ray powder method. Chao and Taylor (1940) are the first to observe the so-called non-Bragg reflexions on plagioclase feldspars in a range from 20~25% to 70~75% *An*. The reflexions were subsequently investigated further by Cole, Sörum and Taylor (1951) and by Sörum (1951). These observations have led to the intensive studies on plagioclase feldspars and a number of researchers have been devoted themselves to the studies, using particularly single crystal techniques, during the past fifteen years. As a matter of course, a large amount of new knowledges about plagioclase feldspars have been accumulated; but, it is becoming more necessary than before to make more intensive and more extensive studies on plagioclase feldspars in order to clarify the various as yet unaccountable phenomena observed on them.

Up to the present, at least seven distinctive lattices are observed on plagioclase feldspars, viz., a low-temperature albite lattice (*C*-centered), a high-temperature albite lattice (*C*-centered), an intermediate lattice (*An*-poor), an intermediate lattice (*An*-rich), a body-centered lattice, a transitional lattice and a primitive anorthite lattice. As far as anorthite is concerned, two kinds of lattice, viz., a transitional lattice and a primitive anorthite lattice are so far found. Some people reported that a body-centered

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lattice was observed when anorthite with the transitional lattice was heated at high temperatures; but, more recent works have cast doubt on such an observation. Precise nature of the transitional lattice is as yet unknown, it is, however, distinguished from the primitive anorthite lattice by diffuse character of the reflexions with $h+k=2n$ and $l=2n+1$, which are called '*c*' reflexions, and absence of the reflexions with $h+k=2n+1$ and $l=2n$, which are called '*d*' reflexions.

Recently the authors have obtained several specimens of anorthite occurred in lava flow. They are about 95% in *An*-content. With these specimens the authors examined their lattice type by taking Weissenberg photographs. In the following, results will be given.

Specimens

Specimens of anorthite used for the present experiments are from Mitaki, Sendai City, Japan. They are found as phenocrysts of andesitic basalt developed at Mitaki area. The phenocrysts are large, not showing zonal structure. The largest ones are about 3 *cm* in their longest direction. The anorthite was studied morphologically by NAKAJIMA (1908), optically by KOZU (1910) and by NEMOTO (1930a, 1930b, 1931) and chemically by KINOSHITA and KAWAI (1923) and by NEMOTO (1930c). The andesitic basalt was studied petrographically and volcanostratigraphically by NEMOTO (1930a, 1930b, 1930c). According to him there crop out four sheets of andesitic basalt being 5~30 *m* in thickness. The sheets had been so far presumed to be extrusive and NEMOTO (1930a, 1930c) concluded that they are lava flow extruded in a period of Neogene, but not at the same time. *An*-content of the anorthite phenocrysts from one of the sheets was optically studied in detail by NEMOTO (1931) and was reported by him that *An*-content of the phenocrysts which were more than 2 *mm* in diameter was variable in a range from 88% to 100% *An* except for their marginal portion, thickness of which is 1/20~1/30 *mm*. Specimens used for the present experiments are from the sheet just said above.

Experimental

Prior to taking X-ray photographs, *An*-content was determined with each of the specimens by measuring the refractive index of glass made by melting the fragment immediately adjacent to that used for X-ray work. The specimens were all about 95% in *An*-content. Rotation and Weissenberg photographs about *a*-axis were taken with slender cleavage splinters using $Cu\text{-}K_\alpha$ radiations. By giving indices to the reflexions respectively which appeared on the zero layer Weissenberg and the 1st and 2nd layer

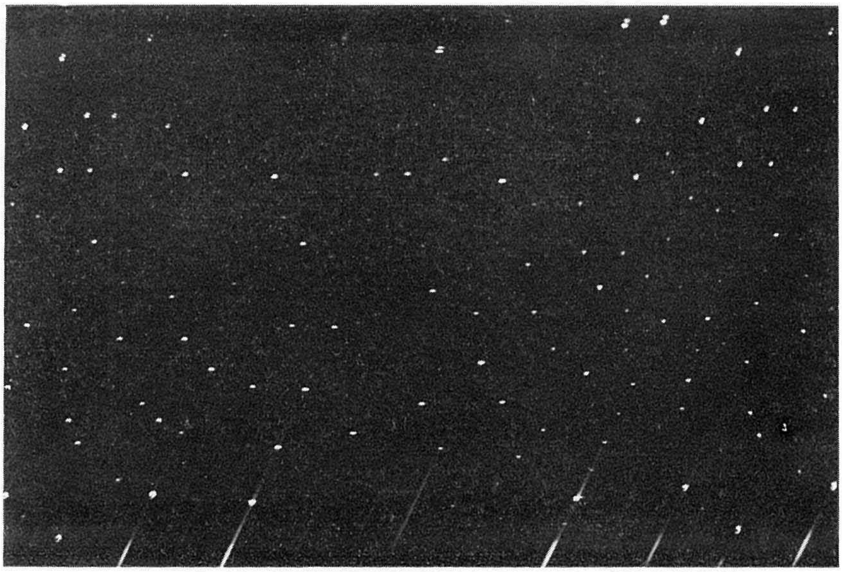

Fig. 1. Zero-layer Weissenberg photograph about *a*-axis, taken with the specimen from Mitaki. (Exposed for 80 hours.) Unfortunately '*d*' reflexions are indiscernible in this duplicate. The reason is that they are essentially very weak in intensity and very few in number.

Fig. 2. Zero-layer Weissenberg photograph about *a*-axis, taken with the specimen from Miyakejima Island. (Exposed for 80 hours.)

equi-inclination Weissenberg photographs, it was found that these specimens are of the primitive anorthite lattice type, since the '*c*' reflexions are sharp and the '*d*' reflexions appear. In Fig. 1 shows the zero layer Weissenberg photograph taken with one of the specimens. In Fig. 2 shows the corresponding Weissenberg photograph of the transitional lattice type for comparison. The photograph was taken with anorthite ejected by the volcanic action in 1874 at Miyakejima Island which belongs to Izu Shichito Islands, Japan, *An*- content of which is also about 95%.

The cell-dimensions and axial angles of the specimens from Mitaki and Miyakejima Island are the same as will be seen below:

Mitaki	Miyakejima
$a=8.18\pm0.01$ Å	$a=8.19\pm0.01$ Å
$b=12.84\pm0.01$ Å	$b=12.84\pm0.01$ Å
$c=14.14\pm0.01$ Å	$c=14.15\pm0.01$ Å
$\alpha=93°11'$	$\alpha=93°13'$
$\beta=115°59'$	$\beta=115°55'$
$\gamma=91°09'$	$\gamma=91°11'$

Consideration

Basing on the reports published by GAY (1953, 1954), GAY and TAYLOR (1953) and by LAVES and GOLDSMITH (1954a, 1954b, 1954c) several particulars will be pointed out as follows:

1. Anorthite with the primitive anorthite lattice is formed at low temperatures or by very, very slow cooling from the high temperatures of formation, provided that *An*-content of which is more than 93~95%.

2. Pure anorthite with the primitive anorthite lattice changes to anorthite with the transitional lattice at about 1100°C, sharp '*c*' reflexions becoming diffuse. Degree of the diffuseness of the '*c*' reflexions increases as the temperature is raised until near the melting point.

3. Anothite with the primitive anorthite lattice, *An*-content of which is 93~95%, changes to anorthite with the transitional lattice at 400°~500°C. Behavior of the '*c*' reflexions is the same as in the case of pure anorthite.

4. Anorthite with the primitive anorthite lattice, *An*-content of which is between 93~95% and 100% changes to anorthite with the transitional lattice at the temperatures between 400°~500°C and about 1100°C, decrease of *An*-content lowering the temperature of the change.

5. Anorthite with the primitive anorthite lattice is not formed in a case when *An*-content of which is less than 93～95%.

6. When anorthite is of the transitional lattice type being at high temperatures, the transitional lattice can be frozen up by the rapid quench, showing the temperature at which the anorthite with the transitional lattice has been quenched by the degree of diffuseness of the '*c*' reflexions.

7. Anorthite with the transitional lattice formed by the rapid quench is transformed to anorthite with the primitive anorthite lattice by annealing below the temperatures at which '*primitive—transitional*' transformation takes place.

Hence, following may be considered: (1) the presence of anorthite with the primitive anorthite lattice in a lava flow may suggest that the cooling of the lava flow was not enough rapid to freeze up anorthite with the transitional lattice, or (2) anorthite with the primitive anorthite lattice in a lava flow might be formed by annealing anorthite in nature, which was once formed as anorthite with the transitional lattice.

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