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A STUDY OF FELDSPAR CRYSTALS FROM NORWAY, MAINE¹

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INTRODUCTION

This paper is the result of an investigation of the crystallographic properties of some feldspar crystals obtained by Dr. Palache in the summer of 1913 from pegmatite veins at Horse Hill, Norway, Maine, and now in the mineralogical collection of Harvard University. The measurement, projection and drawing of the crystals was done in the Crystallographic Laboratory at Harvard, while the optical work was carried out in the Geological Laboratories, of the Massachusetts Institute of Technology.

THE GRANITE

The following description of the granite in which the pegmatite veins occur is made from specimens adhering to the walls of the veins, and owing to its proximity to the pegmatite, this may be somewhat different from the ordinary granite of the region.

The granite is very light grey, almost white, speckled with shiny black biotite crystals, has a medium to fine even grain, and presents a slightly crushed appearance. About 75 percent of the rock is a chalky white, rarely glassy feldspar; about 15 percent is biotite, and about 10 percent dull grey quartz. Irregularly scattered through the rock, especially adjacent to the pegmatite veins are euhedral grains of muscovite, up to three-fourths of an inch across, but averaging three-eighths of an inch, and usually one-fourth of an inch thick. Muscovite of the ordinary size of grain of the rock is also a constituent.

In thin section, the essential minerals are microcline and oligoclase, which by the statistical method give an angle of

¹ This work was done by Mr. J. D. MacKenzie in 1914 as part of his preparation for the Master's Degree. His death in December last cut short a brilliant career and makes one feel that no record of his activities should be lost. The story of his heroic war record and the fine fight he made after fearful wounds to win back to life and work in his chosen field has yet to be told. CHARLES PALACHE.

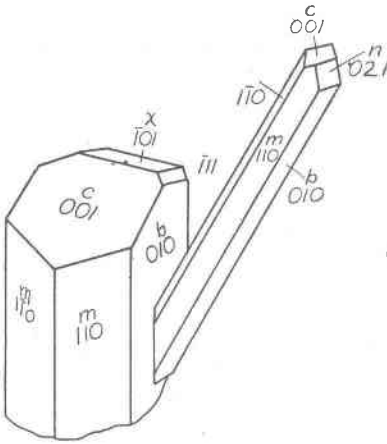


Fig. 1. Microcline. Perspective view.

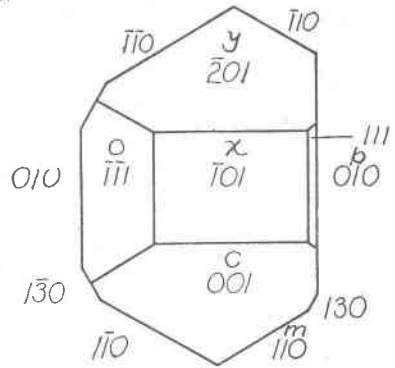


Fig. 2. Microcline. Plan.

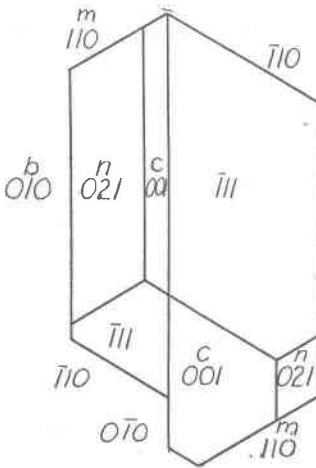


Fig. 3. Carlsbad twin of microcline. Plan.

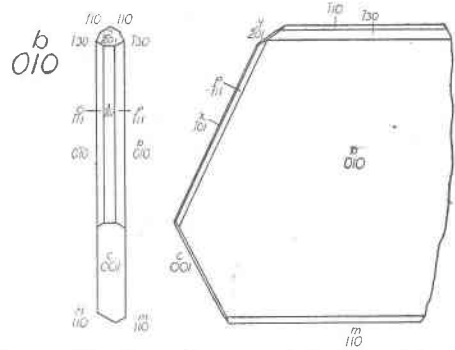


Fig. 4. Oligoclase. Left, plan; right, projection on 010.

extinction of 4° on the albite twinning in equally illuminated twins, corresponding to $Ab_{78}An_{22}$, with which the index of refraction (nearly equal to Canada balsam) and the optical character (negative), agree. Quartz is present also, and shows the wavy extinction caused by stress. Strongly pleochroic biotite and muscovite are subordinate minerals, while apatite and garnet are accessories.

THE PEGMATITE VEINS

OCCURRENCE. All the feldspar, with the exception of the microcline illustrated in figures 11 and 12, came from a single vein. This vein is from 6 inches to 12 inches wide, and is exposed at the surface of the ground for about 100 yards. The specimens taken from it occurred at the surface, but in spite of this many crystals are remarkably glassy and quite unaltered. The contact of the vein with the granite is distinct, with no transition. The feldspar crystals are attached to the sides of the veins and project toward the center, which in the wider portions is composed of quartz molded on the sharply crystallized feldspar. Isolated feldspar crystals are found in this central quartz.

The microcline shown in figures 11 and 12 came from a nearby pegmatite, of which nothing further is known. These crystals measured about 4 by 5 by 6 inches, being thus much larger than the others studied.

MINERALOGY. The minerals observed in the specimens of the pegmatite examined are, in order of abundance, oligoclase, microcline, quartz, muscovite and tourmaline. Brief notes on the minerals other than the feldspars are given here.

The quartz is grey and translucent, greatly crushed and sometimes having a platy fracture. It was the last mineral to cease crystallizing and has molded itself on all the others, in some instances filling cracks in them. The shattered nature of the quartz allows it to be readily broken from around the well-formed feldspar crystals.

The tourmaline is the common black variety, greatly cracked roughly parallel to the base, and re-cemented by quartz.

Muscovite occurs in crystals up to two inches across by three-fourths of an inch thick, and biotite is sparingly present in smaller crystals.

THE FELDSPARS

Both of the feldspars form exceptionally well crystallized individuals. Microcline and oligoclase are found in juxtaposition in groups of crystals, as well as separately crystallized.

MICROCLINE. This mineral forms crystals up to two inches long, of a creamy white tint, and often with a somewhat pearly lustre not seen in the oligoclase. It is more generally altered than the oligoclase, and only rarely is glassy. On the whole, however,

the minerals are very similar in appearance, and frequently can be distinguished only with difficulty. Carlsbad twins are common. The following forms have been observed:

b (010)	z ($\bar{1}\bar{3}0$)
c (001)	x ($\bar{1}01$)
m (110)	y ($\bar{2}01$)
M ($\bar{1}\bar{1}0$)	p ($\bar{1}\bar{1}1$)
f (130)	o ($\bar{1}\bar{1}1$)
n (021)	

Typical crystals are illustrated in figures 1, 2 and 3. Figure 1 shows the usual short, stout variety, terminated principally by the large base and orthodome. The elongate form attached to the stout crystal in figure 1 is of rarer occurrence, and when found is usually in close relationship to the more equant variety, as illustrated. The elongate crystals are commonly Carlsbad twins. The crystal of figure 1 was broken in a number of places by fractures (not shown) virtually at right angles to the prism zone, and these were later healed by quartz. This breaking of the feldspar, often noted in other crystals, may have been concomitant with the shattering of the quartz.

The dimensions of the figured crystals are given in the following table.

	c axis	b axis	a axis
Figure 1 (a)	45 mm.	20 mm	30 mm
Figure 1 (b)	55	10	12
Figure 2	10	7	9
Figure 3	110	50	83

Basal thin sections of the microcline show a very fine, but highly developed grating structure.

The specific gravity, determined by weighing in distilled water at 20°C., is 2.566.

OLIGOCLASE: Crystallography.—The oligoclase crystals are usually white or creamy white, and often in part or wholly glassy and transparent, with a vitreous lustre. The individual crystals are polysynthetically twinned according to the albite law, the plates being in two unequal sets, the thinner ranging from 0.005 mm. to 0.1 mm., and the thicker from 0.02 mm. to 0.3 mm. thick. In addition, the oligoclase is frequently twinned after the Carlsbad, and also after the pericline law. A parting parallel to the latter twinning plane has been noted in some crystals.

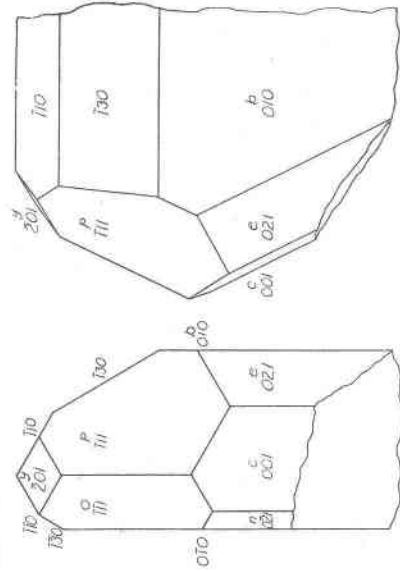


Fig. 6. Oligoclase. Left, plan, right, projection on 010.

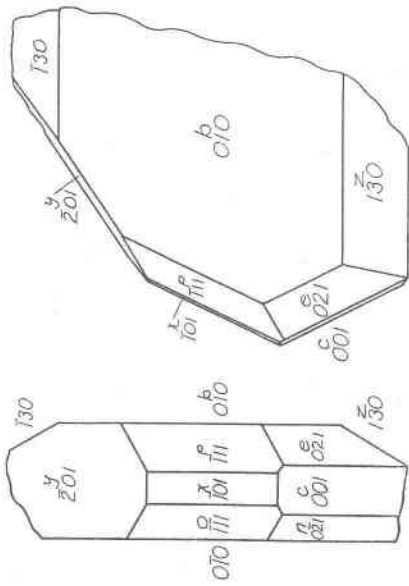


Fig. 5. Oligoclase. Left, plan, right, projection on 010.

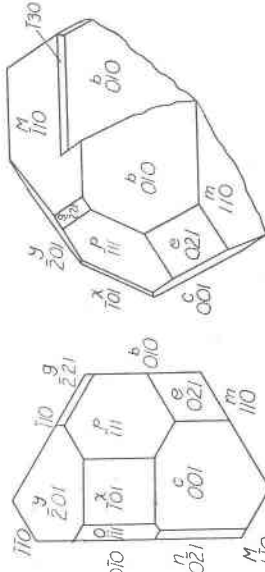


Fig. 8. Oligoclase. Left, plan, right, projection on 010.

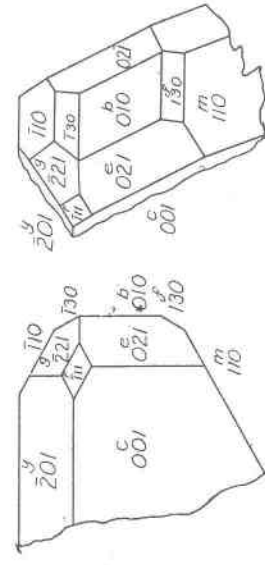


Fig. 7. Oligoclase. Left, plan, right, projection on 010.

Figure 12 is a photograph of a group of oligoclase crystals which illustrates their appearance. There are two principal types in which the oligoclase occurs, as follows:

(1) Equant, stubby crystals, (some of them elongate) pointed owing to the prominence of (021), ($\bar{1}11$) and ($\bar{2}01$), as figures 6, 10 and 11.

(2) Tabular, elongate parallel to (010) as figures 4 and 5. Some noteworthy characters of the oligoclase crystals are:

(1) The prominence of the prism (130) rather than the more usual (110). Figures 4, 5 and 6.

(2) The constant and prominent development of the brachydomes (021) and ($0\bar{2}1$), shown in all the crystals.

(3) The complex, well crystallized, unusual habits for feldspar, shown in figures 7 to 11.

(4) The occurrence of the markedly different tabular and stubby types in a single group of crystals. Figure 13.

The dimensions of the figured crystals are as follows:

	<i>c</i> axis	<i>b</i> axis	<i>a</i> axis
Figure 4.	20 mm.	2 mm.	20 mm.
Figure 5.	17	6	20
Figure 6.	35	15	35
Figure 7.	11	17	18
Figure 8.	38	18	32
Figure 9.	15	20	20
Figure 10.	30	12	20
Figure 11.	28	10	15

The largest oligoclase in the collection measures 65 by 60 by 60mm.

The following forms have been observed:²

<i>a</i>	(100)	<i>x</i>	($\bar{1}01$)
<i>b</i>	(010)	<i>y</i>	($\bar{2}01$)
<i>c</i>	(001)	<i>e</i>	(021)
<i>m</i>	(110)	<i>n</i>	($0\bar{2}1$)
<i>f</i>	(130)	<i>p</i>	($\bar{1}11$)
<i>M</i>	($\bar{1}\bar{1}0$)	<i>g</i>	($\bar{2}\bar{2}1$)
<i>z</i>	(130)	<i>o</i>	($\bar{1}\bar{1}1$)
	<i>a</i>		($\bar{1}\bar{1}1$)

OPTICAL PROPERTIES.—*Extinction angles*.—The extinction angles

² The crystals were measured with the contact goniometer, none of the faces being of reflecting quality. The zonal relations served to fix the character of the faces of more complex indices.

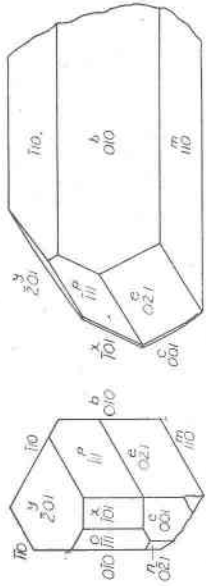


Fig. 10. Oligoclase. Left, plan; right, projection on 010 .

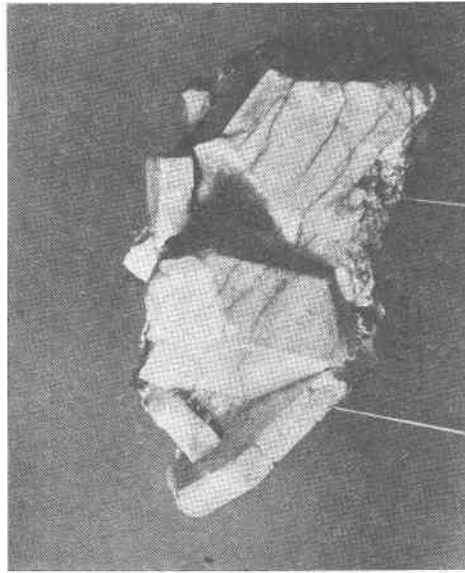


Fig. 12. Groups of oligoclase crystals illustrating the association of thin-tabular and equant stubby individuals.

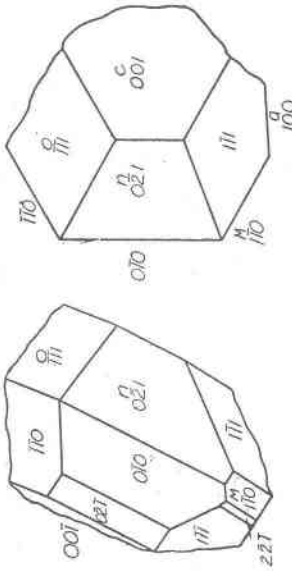


Fig. 9. Oligoclase. Left, projection on 010 ; right, plan.

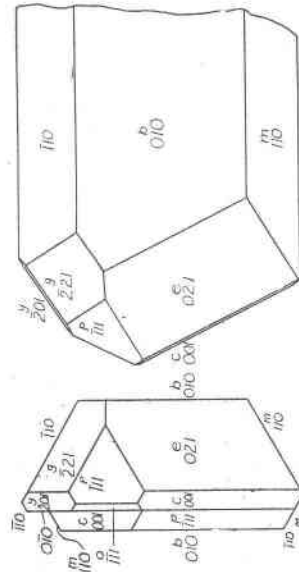


Fig. 11. Oligoclase. Carlsbad twin. Left, plan; right, projection on 010 .

of the oligoclase were measured on cleavage flakes obtained by crushing the feldspar to pass a 40 and remain on a 60 mesh sieve.

EXTINCTION ON 001 CLEAVAGE FLAKES.—The crushed fragments showing albite twinning did not afford satisfactory measurements, as the two sets of twinning lamellae were of different widths, one being constantly wider than the other, the difference being usually from 5 to 15 times the width of the narrower twin. The lamellae were not always straight, which also caused difficulty.

A thin section made from a basal cleavage plate gave the following values, which are the mean of ten readings in each position. The sensitive tint was used to determine the position of extinction of the lamellae, and the angles were measured from the trace of the 010 cleavage. The values given are probably correct within ten minutes for the first, and fifteen minutes for the second.

(1) Extinction angle of wider lamellae = $2^{\circ}43'$

(2) " " " narrower " = $1^{\circ}00'$

The first value corresponds very nearly to the composition $Ab_{85}An_{15}$,³ and the second to $Ab_{75}An_{25}$. It is, of course, not considered that this apparent discrepancy in composition of the two sets of lamellae exists; rather is it explained by the difficulty of measuring the extinction accurately on the narrower bands, although the difference seems larger than can be accounted for in this way.

It is probable that the value $Ab_{85}An_{15}$ more nearly represents the true composition of the oligoclase, for the values obtained from extinction on the 010 face and the indices of refraction agree fairly well with this one.

EXTINCTION ON 010 CLEAVAGE FLAKES.—These flakes, recognized by the absence of twinning, were sharply bounded on two sides by the excellent 001 cleavage. The extinction angles in various flakes obtained from a small portion of a single crystal showed closely, though not absolutely accordant results. One flake gave as a mean of ten readings the extinction angle $10^{\circ}47'$, probably accurate (for this flake) within $5'$. No deviations in other flakes of over a degree from this value were noted. The angle $10^{\circ}47'$ corresponds to a composition $Ab_{83}An_{17}$, which checks

³ Schuster's values as given by Johannsen, *Rock-forming Minerals in Thin Section*, Wiley & Sons, *New York*, N. Y., 1908, p. 79.

fairly well with $\text{Ab}_{85}\text{An}_{15}$, obtained from a measurement on the wider lamellae in a basal section.

OPTICAL CHARACTER.—The optical character of the oligoclase has been determined as negative.

INDICES OF REFRACTION.—Indices of refraction were measured by immersing cleavage flakes in liquids whose indices were known, and comparing the refraction of the flakes with that of the liquid. In this way, n_γ was found to be somewhat less than 1.554, and n_α about equal to 1.542. These values correspond to an oligoclase slightly more basic than the extinction angles indicate.

SPECIFIC GRAVITY.—The specific gravity of the oligoclase, determined by weighing in distilled water at 20°C, is 2.631. This agrees with the optical determinations of the high albite content of the mineral.

REMARKS.—While the various results of determining the composition of the feldspar as detailed above agree fairly well among themselves, they are not as strictly accordant as one would ordinarily expect when it is considered that the measurements were made on orientated sections of very fresh material. When under these favorable conditions such discrepancies arise, the need of caution in stating the composition of feldspar as determined by optical tests on unorientated crystals in a thin section is apparent.

THE COLORING OF THE DIAMOND BY RADIUM RADIATION*

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in Cooperation with the University of Nevada*

The results of various investigators attempting to color the diamond by radium radiation have not been entirely uniform and in the main were unsuccessful. Doelter¹ classes diamond as the most difficult of all minerals to color, and reports for the most part failures or very slight coloring. On the other hand,

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¹C. Doelter, "Das Radium und die Farben," Steinkopff, Dresden, 1910, p. 123.