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OPTICAL PROPERTIES OF ADIRONDACK ANORTHOSITE PLAGIOCLASES

A. C. ONYEAGOCHA[1] AND K. E. SEIFERT, *Department of Earth Science Iowa State University, Ames, Iowa 50010.*

ABSTRACT

Adirondack anorthosite plagioclases exhibit compositional frequency peaks at An_{42} to An_{45} and An_{49} to An_{51} with the second peak being strongest. Albite and pericline twins are most abundant in groundmass plagioclase, whereas Carlsbad and albite-Carlsbad are sometimes most abundant in plagioclase megacrysts. Plagioclase structural states range from medium transitional to more ordered than existing low structural state curves. Values of 2V show considerable scatter over the entire anorthosite.

INTRODUCTION

The purpose of this study is to define the variation in optical properties of Adirondack anorthosite plagioclases. In order to obtain a representative sample of the main anorthosite massif, samples were collected over the entire massif, largely from along roads and trails. All samples were collected during the summer of 1967. The Adirondack anorthosite has characteristically been field mapped as either Marcy facies or Whiteface facies and each sample was labeled as either Marcy or Whiteface facies. Therefore data is presented for each facies separately, although they are very similar. Plagioclase was studied in three perpendicular thin sections in a total of 34 samples, 17 from each facies, using a petrographic microscope and 4-axis universal stage. Study included 522 groundmass crystals from the Marcy facies and 525 groundmass crystals from the Whiteface facies. Optical properties of 29 megacrysts from the Marcy facies and 6 from the Whiteface facies were determined. Optical properties determined are composition, structural state, twinning, and $2V_z$.

Optical properties were determined using Slemmons (1962) diagrams. Some crystals were restudied on a 5-axis universal stage and plotted on the diagrams of Burri, *et al.* (1967). The results were always very similar. Only a summary of the data is presented here. A complete tabulation of the data for each sample is given by Onyeagocha (1970).

PROPERTIES OF THE PLAGIOCLASES

Composition. The range of groundmass plagioclase composition within individual samples is from four to twenty one percent anorthite. In the sample with a variation of twenty one percent anorthite only two crystals have compositions of An_{32} and An_{34} whereas all of the others are between

[1] Now at Dept. of Geological Sciences, University of Washington, Seattle, Washington 98105.

An_{48} and An_{53}. Groundmass plagioclase compositions show a bimodal frequency distribution (Fig. 1) with a smaller peak at An_{42} to An_{45} and a larger peak at An_{49} to An_{51}. The larger peak to An_{49} at An_{51} is due to Whiteface plagioclases which ranges from oligoclase (An_{11}), in one sample, to labradorite (An_{57}) in composition (Fig. 2). The Marcy plagioclases exhibit a more limited compositional range (An_{37} to An_{58}) and are represented by the less pronounced frequency peak between An_{42} and An_{45} (Fig. 3). The composition of 29 Marcy megacrystals studied ranges from An_2 to An_6 more calcic than that of groundmass plagioclase from the same sample. The 6 Whiteface megacrystals studied appear to have about the same composition as the groundmass plagioclase.

Twinning. Most plagioclase crystals are twinned according to a single law although a sizable proportion have more than one law. Of the total 1117 twins determined in the Adirondack anorthosite groundmass plagioclase, 74 percent were albite and 23 percent were pericline. The other 3 percent are Manebach, Ala-B, Ala-A, albite-Ala B, and Carlsbad. The relative abundances of the twin laws in the Marcy and Whiteface facies is very similar.

Carlsbad and albite-Carlsbad twin laws predominate over albite and pericline twin laws in the megacrysts from some samples. In other samples both megacrysts and groundmass were twinned according to the albite and pericline laws. Field observations indicate that simple twins

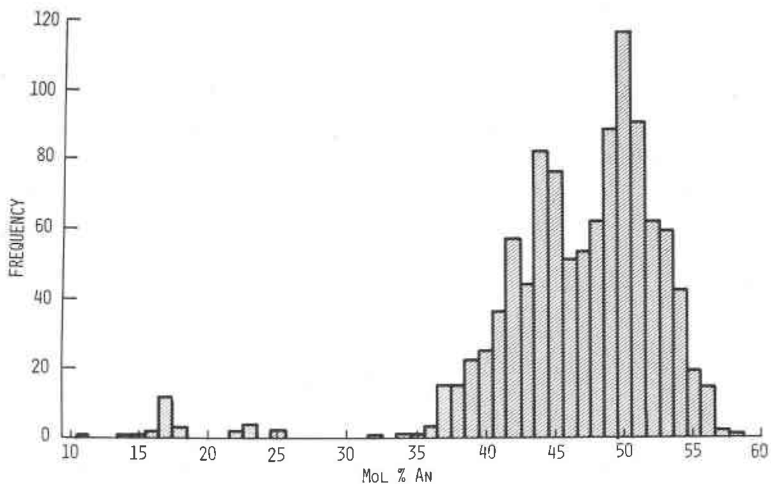

FIG. 1. Compositional frequency of all Adirondack anorthosite plagioclases (Whiteface and Marcy facies).

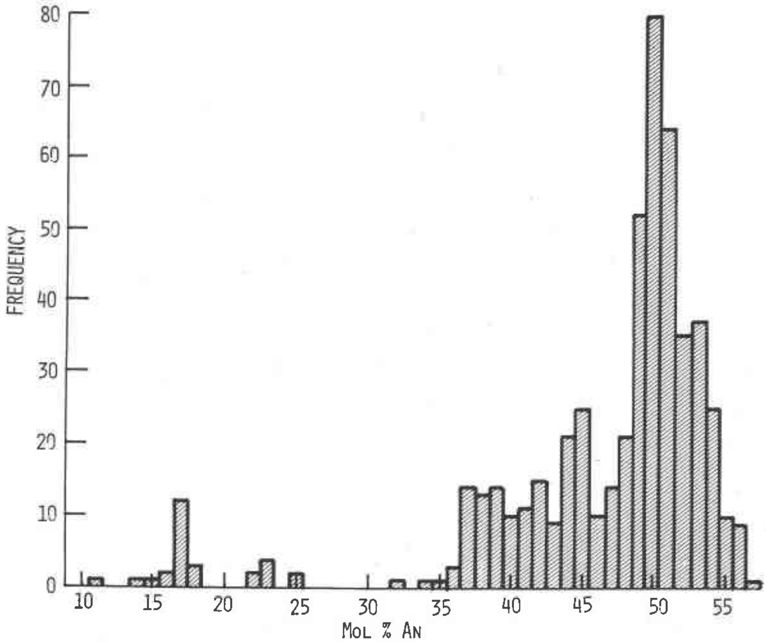

FIG. 2. Compositional frequency of Whiteface anorthosite plagioclases.

of equal width, such as the Carlsbad and albite-Carlsbad twins observed in thin section, are common in plagioclase megacrysts in certain localities of the Adirondack anorthosite.

Structural State. Figure 4 is a cummulative plot showing structural states of all crystals from Whiteface and Marcy groundmass plagioclase twinned according to the albite law. Figure 5 displays structural states of all groundmass crystals from Whiteface and Marcy facies twinned according to the pericline law. These cummulative plots vary from intermediate structural state through low-temperature structural state to structural states representing crystals more ordered than those used in constructing the curves. Groundmass and megacrysts show roughly the same degree of order-disorder.

Optic Angle ($2V_z$). Measurements of the optic angle indicates that $2V$ fluctuates widely over the entire anorthosite. Values of $2V_z$ plotted on the curves of Burri, *et al.* (1967) (Fig. 6), for Whiteface and Marcy groundmass plagioclase, show transitional structural states for compositions up to about An_{45}. At compositions more calcic than An_{45} the high

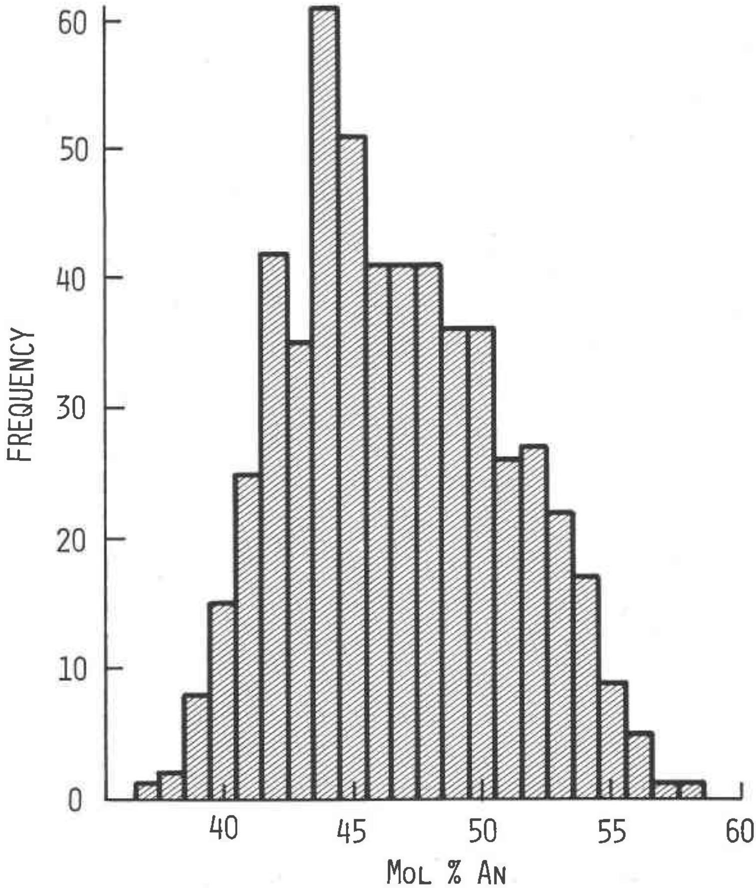

FIG. 3. Compositional frequency of Marcy anorthosite plagioclases.

and low structural state curves are very close for $2V_z$, and the scatter of $2V_z$ data is so great that it is virtually useless as an indicator of structural state. There appears to be no difference between $2V_z$ plots of Whiteface and Marcy anorthosite plagioclase.

SIGNIFICANCE OF DATA

Three criteria have been employed by field workers in distinguishing between the Marcy and the Whiteface facies of the Adirondack anorthosite complex: percent megacrysts versus groundmass, foliation versus non-foliation, and percent mafics versus plagioclase. Any or all of the criteria appear to have been used to distinguish between the facies during field mapping. Although plagioclase compositions are somewhat differ-

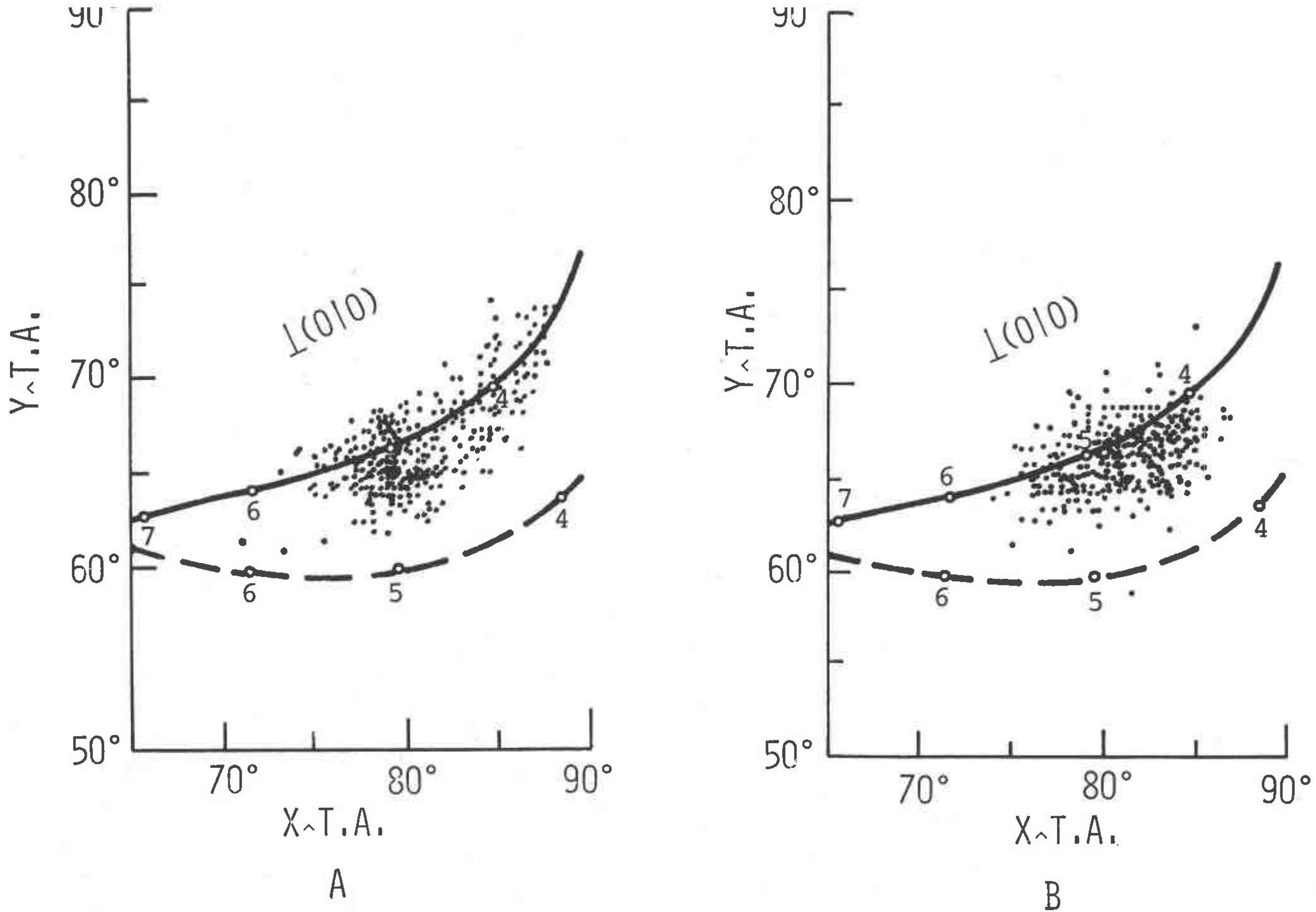

FIG. 4. Twinning-axis plots for albite twins observed in (A) Whiteface anorthosite and (B) Marcy anorthosite. Solid curves are for plutonic plagioclase and dashed curves are for volcanic plagioclase (Curves from Slemmons, 1962).

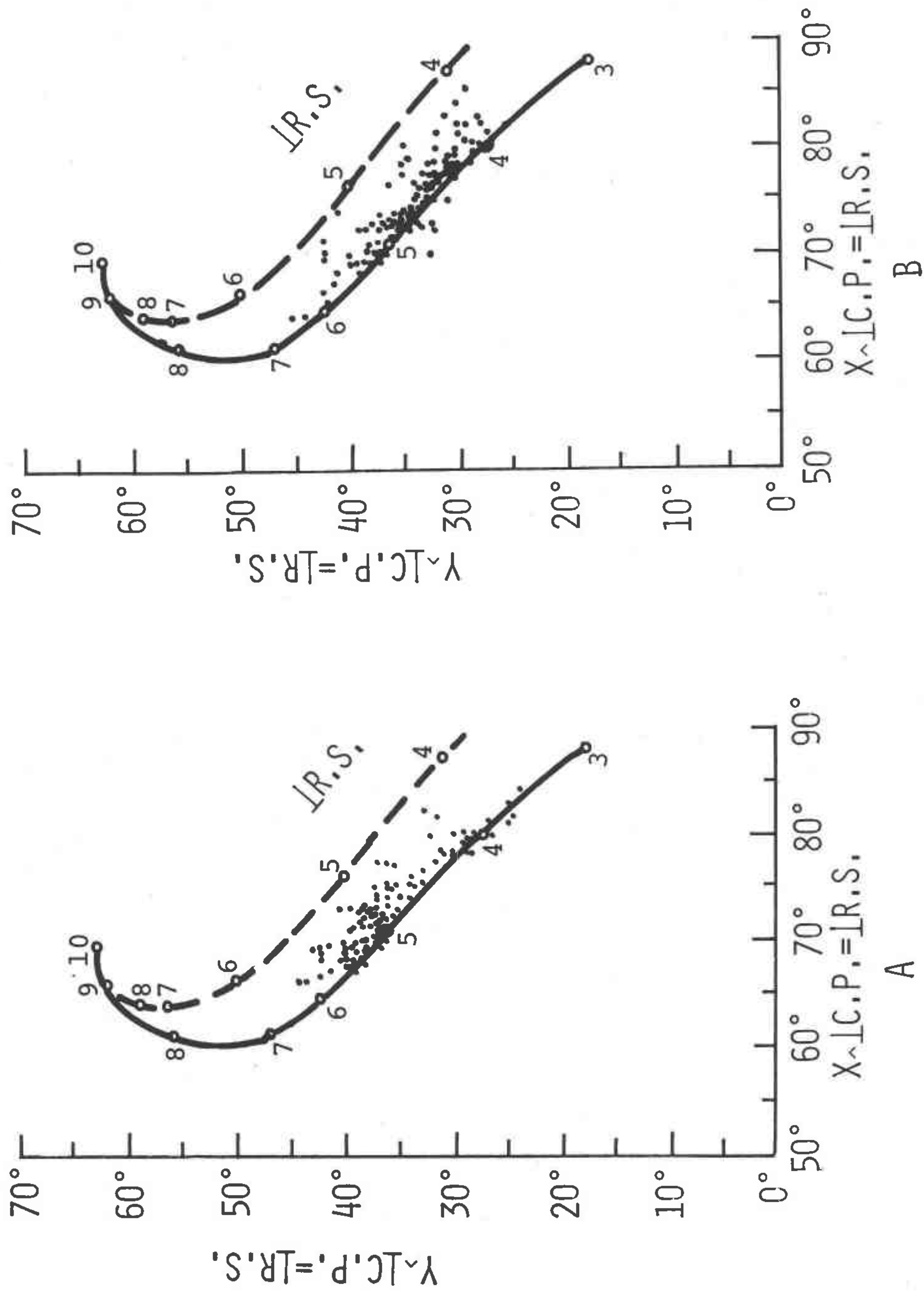

FIG. 5. Twinning-axis plots for pericline twins observed in (A) Whiteface anorthosite and (B) Marcy anorthosite. Solid curves

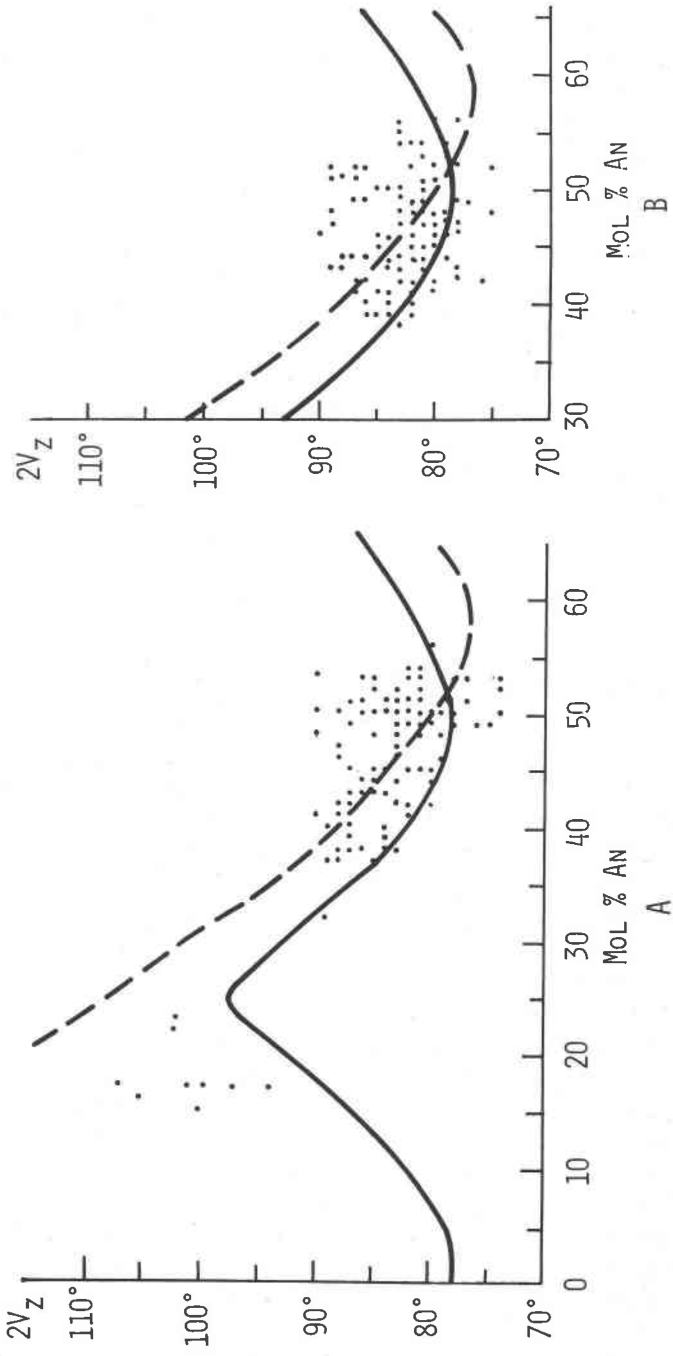

FIG. 6. Variation of optic angle ($2V_z$) relative to plagioclase composition for (A) Whiteface anorthosite and (B) Marcy anorthosite. Solid curves are for plutonic plagioclase and dashed curves are for volcanic plagioclase (Curves from Burri, *et al.*, 1967).

ent in the two facies it does not appear that the properties of the plagioclases are sufficiently different to serve as an additional means of separating the two facies.

Plagioclase compositions of Whiteface and Marcy anorthosites fall within a range in which the closeness of the high and low structural state curves makes $2V_z$ a poor criterion to define composition and structural state. The values of $2V_z$ found in the anorthosite show a large scatter that is very similar in both facies. The large scatter of $2V_z$ might be due to strain as observed by Borg and Heard (1969). Perhaps the strain is large enough to affect the strain sensitive optic angle while insufficient to disturb other properties.

The more calcic composition of plagioclase megacrysts relative to groundmass in Marcy anorthosite may be due to a later metamorphic reaction between groundmass plagioclase and pyroxene to produce garnet and quartz according to (Turner, 1948, p. 27):

$$\underset{\text{pyroxene}}{2(MgFe)SiO_3} + \underset{\text{anorthite}}{CaAl_2Si_2O_8} \rightarrow \underset{\text{garnet}}{CaFe_2Al_2Si_3O_{12}} + \underset{\text{quartz}}{SiO_2}$$

Such a reaction would leave the groundmass plagioclase more albitic. It might be expected that the anorthosites containing garnet would be especially prone to show groundmass plagioclase that is more sodic than plagioclase megacrysts.

The twinning frequency in Adirondack groundmass plagioclase is in agreement with that found by Gorai (1951) and Turner (1951) to be characteristic of metamorphic rocks. Approximately 97 percent of all twins in the Adirondack anorthosite groundmass plagioclases are albite and pericline, figures which conform to the abundance of these two twin laws in metamorphic rocks. Only 27 of the 1117 twins determined are not albite and pericline twins. The lack of igneous type twins, such as Carlsbad, albite-Carlsbad, Maneback, and Baveno twins, would seem to indicate that the groundmass plagioclase of the igneous Adirondack anorthosite was recrystallized and retwinned during a later metamorphism.

The ordered structural states indicate that the Adirondack anorthosite cooled very slowly. Either the very slow cooling or the intense confining pressure at its great depth of solidification probably caused the plagioclases to become more ordered than those used to determine standard ordering curves.

In samples with considerable potash feldspar, plagioclase is more sodic than normal. Consequently the presence of potash feldspar serves as an indicator of more sodic plagioclase in the anorthosite.

Acknowledgements

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