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ON THE DIFFERENCE IN TWINNING BETWEEN PHENOCRYST AND GROUNDMASS PLAGIOCLASE OF BASALTS

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INTRODUCTION

In the course of a study of the Jurassic Rajmahal basalts of Santal Parganas, Bihar, India, some arresting features were observed in the mode of twinning of the plagioclase. Albite, Carlsbad, pericline and albite-Carlsbad twins are very common in both phenocryst and groundmass plagioclases; Baveno, Manebach and interpenetration twins are much rarer and confined to the phenocrysts. Preliminary thin-section study indicated certain other conspicuous differences in the twinning of the phenocryst and groundmass plagioclases. To more accurately assess these differences, statistical study of certain aspects of twinning of these plagioclase grains was undertaken. Very few comparative data are available on the differences in twinning between phenocryst and groundmass plagioclases, though Gorai (1951, p. 886) has observed that "There are no marked differences in the type of twinning between the phenocrysts and groundmass of plagioclases, except that the former are somewhat richer in pericline (acline) and rare twins (Manebach etc.)." Emmons and Mann (1953, p. 53) have stated, "The phenocrysts in porphyritic rocks are customarily untwinned or weakly twinned."

METHOD OF STUDY

First the plagioclase grains were classified into 3 groups: (i) L group to include all lamellar multiple twins, (ii) S group to include all simple binary twins and (iii) U group to include all untwinned grains. For the purpose of this study, the grains in which a simple twin law (*e.g.* Carlsbad) was combined with a lamellar twin law (*e.g.* albite) were classed with the L group. The object was to distinguish between grains containing lamellar twins, grains containing no lamellar twin and only simple twins, and grains containing no twin. The relative proportion of U, S and L types of grains was determined for both the phenocryst and groundmass plagioclases in each thin section. In a traverse of each slide 100 grains of groundmass plagioclase were studied, each being classed in one of these three categories. The percentage frequency of the three types was then plotted on a U-S-L triangular variation diagram (Fig. 1). About 30 basaltic rocks from different parts of the Rajmahal hills were studied. Next, the percentage frequency of the U, S and L types in the phyric plagioclase was determined for each rock by using all the available phenocrysts (varying from 2 to 16) in each thin section. These figures were also plotted on the U-S-L diagram. Data for the phenocryst fraction of about 50 samples of the Rajmahal basalt are shown. Figure 1 brings out prominently the difference in twinning between the phenocryst and groundmass plagioclases of the Rajmahal basalt. The groundmass plots exhibit a relative concentration towards the 'L' vertex of the triangle and away

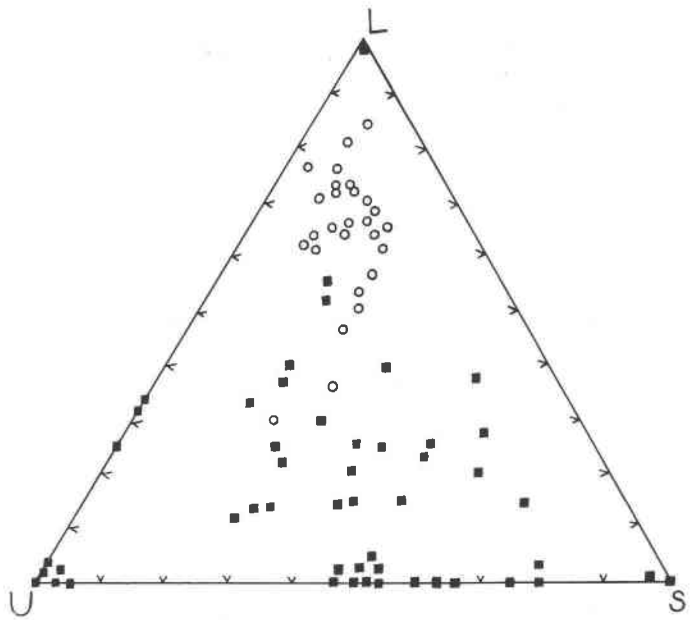

FIG. 1. U-S-L triangular diagram showing difference in twinning between phenocryst plagioclase (represented by squares) and groundmass plagioclase (represented by circles) in the Rajmahal basalts.

from the 'U-S' join while the phenocryst plots do just the reverse. Though there is considerable scattering of data, the diagram clearly demonstrates that the incidence of lamellar or polysynthetic twinning is much greater in the groundmass plagioclase than in the phenocrysts and that the proportion of simple binary twins and untwinned single crystals is much higher in the latter.

Second the morphological characters of the twin lamellae were studied. The typical twin-zone relations on 'a'—normal sections, usually taken (Vance, 1961) as evidence of primary twinning, were often recognized. Moreover, the lamellae in the multiple twins are usually irregular and variable in width. They commonly do not traverse the full length of the crystal, terminating abruptly halfway across it. Mostly they lack bending or other obvious signs of strain and the characteristic uniformity of glide lamellae. Most of the lamellar twinning in these rocks would therefore appear to be primary. Among the phenocrysts, particularly simple-twinned phenocrysts, some crystals show evidence (Ross, 1957, p. 650) of having formed by a combination of more than one separately grown individual, according to some twin law. These twins may be regarded as secondary. Some other crystals, however, show concentric zoning around a single core, the core and zones being shared between the two twin halves, more or less equal in dimension. These may be growth twins (primary). In many cases the evidence is not clear-cut.

Table 1. Lamellar Width of Polysynthetic Twins in Rajmahal Basalts

Plagioclase	Lamellar width in mm	
	Range	Average value
Phenocryst	0.010 to 0.240	0.089 (100 grains)
Groundmass	0.0033 to 0.0091	0·0057 (3000 grains)

Finally, the width of the individual lamellae in the polysynthetic twins were measured. The results (Table 1) show a conspicuously greater average lamellar width for the phenocrysts than for the groundmass.

Discussion of the Results

The frequency of twinning of phenocryst and groundmass crystals shown on the variation diagram indicates that formation of lamellar twins was greatly favored in the groundmass crystals relative to the phenocrysts. The greater frequency of lamellar twinning in the groundmass plagioclase is confirmed by the relative lamellar width of the phenocryst and groundmass twins. It may be assumed that growth of plagioclase is much faster during the post-eruptive stage of groundmass crystallization than at the pre-eruptive stage of phenocryst formation. Twinning in the Rajmahal plagioclase was probably favored by conditions of rapid growth. If the twinning studied here (particularly the lamellar twinning) is largely primary, as suggested by the petrographic evidence, this study may be regarded as a confirmation of the theory that primary twinning is favored by conditions of rapid crystallization, as proposed by Buerger (1945) and since supported by many others (*e.g.* Seifert, 1964).

The lamellar width and frequency of twinning in plagioclase was once believed to be exclusively a function of plagioclase structure and composition (Donnay, 1940; 1943). In the Rajmahal plagioclase the average composition of the phenocrysts and the groundmass are approximately An_{65} and An_{58} respectively. This difference of 7 per cent anorthite is perhaps too small to explain by itself the conspicuous contrast in their twinning. It is now recognized by many that the lamellar width is also dependent on external environmental conditions of crystallization (Gorai, 1951; Smith, 1958; Gay, 1956; Vance, 1961). Some of these workers have expressed the extreme view that lamellar width is governed almost entirely by external factors such as velocity of crystallization and euhedral growth habit and is little influenced by structural or compositional controls.

This work was carried out in the Department of Geology, Presidency College, Calcutta. Most of the rock specimens supporting this study were collected by the writer, the others were obtained from the museum of this Department.

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DEFORMATION BANDS IN ALBITE

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Introduction

An albite crystal collected from a pegmatite near Bethel, Maine shows long narrow deformation bands oriented approximately normal to (010). In thin section, between crossed nicols, these bands become readily visible due to the difference in extinction position and the bending of intersecting twin lamellae and are associated with small boundary fractures