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DYNAMIC INTERPRETATION OF THE FABRIC OF A DOLOMITE FROM THE MOINE THRUST-ZONE IN NORTH-WEST SCOTLAND

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ABSTRACT. Petrofabric studies on naturally and experimentally deformed dolomite indicate that the main mechanisms of plastic deformation of dolomite, under most conditions, are twin-gliding on $\{02\bar{2}1\}$ and translation-gliding on $\{0001\}$. The fabric of a dolomite with mylonitic textures is analysed and interpreted in dynamic terms. The grains in the rock contain numerous $\{02\bar{2}1\}$ twin lamellae and also internally rotated lamellae of the type observed in experimentally deformed dolomite and designated L_θ. Compression and tension axes inferred from twinned $\{02\bar{2}1\}$ lamellae are statistically parallel to those inferred from L_θ lamellae. The strain calculated from the amount of rotation of L_θ lamellae varies from 5 to 18 percent for individual grains; it is concluded that these figures are probably less than the total post-crystalline strain in the rock.

INTRODUCTION

Recent fabric studies of experimentally deformed dolomite rock (Turner, Griggs, Heard, and Weiss, 1954; Handin and Fairbairn, 1955) and of single crystals of dolomite (Higgs and Handin, 1954) have elucidated the mechanisms of plastic deformation of dolomite at temperatures below 400°C. The present paper describes the fabric of a dolomite tectonite from the Moine Thrust-zone in the Assynt district of Sutherland, Scotland.[1] The fabric of this specimen is of particular interest as some of its constituent grains contain internally rotated lamellae of the type recorded in experimentally deformed dolomite but not hitherto described in naturally deformed rocks. A dynamic interpretation of the $\{02\bar{2}1\}$ twin lamellae and rotated lamellae is made in the light of the experimentally established data, and the mechanism of deformation of the rock is tentatively discussed.

INTRAGRANULAR DEFORMATION OF DOLOMITE

Inferred from Natural Fabrics.—The first detailed study of dolomite orientation in deformed rocks was made by Fairbairn and Hawkes (1941). Analyses of the orientation of the lattice and twin lamellae in a number of specimens from Montana, Vermont and Ontario were recorded and a possible mechanism of deformation was inferred from the data. The authors found that $\{02\bar{2}1\}$ twin lamellae were extensively developed in all the specimens, and the orientation of the lamellae in the fabric of the rocks led them to conclude that the sense of gliding in twinning on $\{02\bar{2}1\}$ was opposite to that for twinning on $\{01\bar{1}2\}$ in associated calcite. They considered that translation-gliding on $\{0001\}$, which had been produced experimentally by Johnsen (1902), might also be of some importance as an orienting mechanism, though this would be difficult to prove in view of the difficulty of identifying the process by optical means.

In a comprehensive study of Alpine dolomite-tectonites, Ladurner (1953)

[1] The specimen (M14) was collected from a body of crystalline dolomite underlying the Moine Thrust at Benmore Lodge near Loch Ailsh. It is one of five similar specimens analyzed as part of a detailed structural study of the area. The fabrics of the remaining four specimens are described elsewhere (Christie, 1956) and related to the visible megascopic structures in the rocks of the thrust-zone.

recorded the orientation of [0001]-axes in more than 40 specimens from various parts of the Alps. On the basis of the preferred orientation of [0001]-axes he classified the rocks into *S*-tectonites and three types of *B*-tectonite, according to the number of *s*-planes and symmetry planes which he recognized in the fabrics. The similarity between synoptic diagrams showing maxima of [0001]-axes in dolomite-tectonites and analogous diagrams for calcite-tectonites led Ladurner (1953, p. 290, 296) to assume that the same mechanism was responsible for producing the preferred orientation in dolomites as was postulated by Felkel (1929) for calcite: namely, gliding on $\{01\bar{1}2\}$, combined with rotation of the $\{01\bar{1}2\}$ planes about the *B*-axis of the fabric. This conclusion is invalidated by the experimental work of Turner, Griggs and Heard (1954), who have shown that translation-gliding in calcite occurs, not on $\{01\bar{1}2\}$, as thought by Felkel, but on $\{10\bar{1}1\}$, and at room temperatures on $\{02\bar{2}1\}$. Moreover, experimental work on dolomite up to the present time (see below) gives no indication that gliding on $\{01\bar{1}2\}$ occurs in dolomite, nor is such a mechanism compatible with the geometry of the dolomite lattice.

Determined by Experimental Deformation of Dolomite.—Early attempts to produce twinning experimentally in dolomite were unsuccessful but Johnsen (1902) recorded translation-gliding in deformed crystals with {0001} as the glide plane and one of the *a* crystal axes as the glide line. More recently two glide mechanisms were demonstrated for dolomite (Dover Plains dolomite rock) compressed 9.4 percent at 380°C and 3,000 atmospheres confining pressure (Turner, Griggs, Heard and Weiss, 1954):

1. "twin-gliding on $\{02\bar{2}1\}$, the sense of shear being such that the upper layers of the crystal lattice are displaced downwards from the upper end of the *c*-axis," that is, with a *negative* sense of shear (Turner, Griggs and Heard, 1954, p. 897);
2. "translation-gliding on {0001}, with the *a*-axes as probable glide directions."

Deformation of single crystals of dolomite at room temperature and at 300°C (Higgs and Handin, 1954) confirms the above conclusions: the crystals deformed at 300°C by translation-gliding on {0001} and by twin-gliding on $\{02\bar{2}1\}$ with a negative sense of shear; the latter mechanism was not identified in crystals deformed at room temperature. Twin-gliding on $\{02\bar{2}1\}$ was also found by Handin and Fairbairn (1955) in their experiments on Hasmark dolomite rock. Bradley, Burst and Graf (1953) have shown, moreover, that these two glide mechanisms would account for the progressive changes observed in the lattice of dolomite after prolonged grinding.

DYNAMIC INTERPRETATION OF LAMELLAE IN NATURALLY DEFORMED DOLOMITE ROCK

Inferences of two independent kinds, concerning the dynamics of deformation, may be drawn from $\{02\bar{2}1\}$ lamellae in naturally deformed dolomite rocks:

The first is analogous to the dynamic interpretation of twin lamellae in calcite marbles, described by Turner (1953). Figure 1a shows the orientation of $\{02\bar{2}1\}$ twin lamellae in relation to the [0001]-axis in dolomite twinned on