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Olivine recrystallization textures

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SUMMARY. Mosaic olivine textures, with straight triple grain boundaries meeting at angles of 120°, are common in dunites. This is a well-known feature of annealed metals, and is the result of grain-boundary migration during recrystallization in which the system tends toward a state of minimum interfacial energies. Geometrically similar textures are present at the boundaries between such mosaic grains and strain-banded relict olivine grains. The unstrained mosaic grains make angular projections into the strained grains exactly at the junctions between the deformation bands. These are interpreted to be triple junctions with the two differently oriented bands acting as separate grains, and thus also due to recrystallization.

BOTH Lauder (1965, p. 479) and Challis (1967, p. 200) have drawn attention to certain textural relationships involving strain-banded olivine grains in dunite, and both interpret these features in terms that support their general contention that the intrusions of the New Zealand peridotite belt are the product of essentially magmatic processes. The purpose of this note is to propose an alternative explanation.

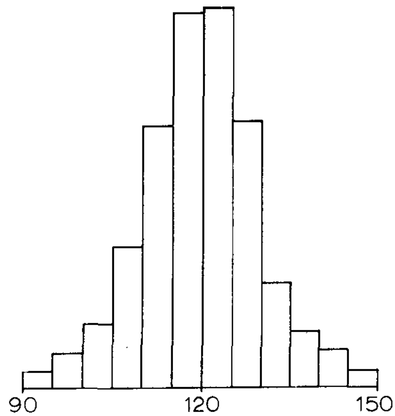
The textural element in question is the geometry of the boundary between olivine grains with pronounced undulatory extinction bands and the adjacent smaller unstrained grains. At these boundaries the surrounding grains often make angular projections into the strained grain with points exactly at the junctions between the extinction bands. Although Lauder and Challis are apparently the first to comment, it is quite a common feature in many dunites, both from intrusive masses and from inclusions found in basalt. One of the best examples is figured by Rieker and Seifert (1964, p. 3909).

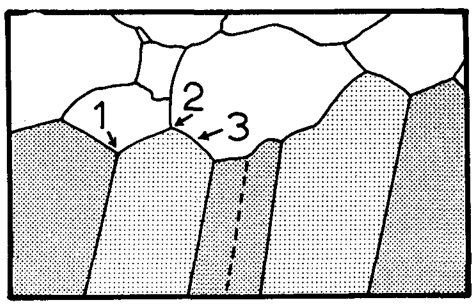
I have previously described a number of different recrystallization textures found in dunites (Ragan, 1963, 1967; Foster *et al.*, 1966; Forbes and Ragan, 1967). One feature in particular is of interest: in common with recrystallized metals (see McLean, 1957, pp. 44–68), metamorphic minerals often exhibit a mosaic texture with equidimensional grains with straight boundaries that meet at triple junctions with angles of approximately 120° (Rast, 1965; Kretz, 1966). This same mosaic texture has also been reported for olivine (Talbot *et al.*, 1963, p. 171). Fig. 1 gives the results of universal stage measurements of 300 grain boundary angles of such mosaic olivine from a dunite of an Antarctic inclusion suite; the angles show a unimodal and symmetrical frequency distribution with a sharp peak at 120°.

The configuration of straight grain boundaries meeting at angles of 120° minimizes the interfacial energies of the mosaic grain. Therefore, during annealing recrystallization the grain structure tends toward this state and clearly this characteristic texture is proof of such recrystallization.

Probably the most important reason for departure of the angles from exactly 120°

is failure of the system to reach equilibrium. In dunites there are two evidences of such disequilibrium: curved grain boundaries and, more important, the presence of ragged, often large, severely strained relict grains. The contact between these relicts and the surrounding recrystallized mosaic grains is, therefore, of particular interest. From fig. 2 it will readily be apparent that the geometry of this contact is also the result of recrystallization. These inward angular projections are simply triple junctions with





FIGS. 1 and 2: Fig. 1 (left). Frequency distribution of boundary angles of mosaic olivine grains. The class interval is 5°; the interval 116–25° contains 42 % of the measured angles (after Forbes and Ragan, 1967; and in preparation). Fig. 2 (right). A single strain-banded olivine grain in contact with smaller unstrained grains (after Rieker and Seifert, 1964, p. 3909). Point 1: triple grain boundary with junction at a band boundary. Point 2: triple junction involving a single band. Point 3: curved grain boundary, characteristically with centre of curvature in the strained grain.

the two differently oriented, adjacent deformation bands acting as separate grains during grain boundary migration. Similarly, outward projections of identical form are also present for identical reasons; here the individual bands act as single grains.

Generally the grain boundaries between the mosaic and strained grains are curved. In metals it is known that grain boundaries migrate toward their centres of curvature. In the olivine, these centres lie in the strained material, and this confirms that these relicts were in the process of being eliminated during recrystallization.

The reinterpretation of these textures as being due to the recrystallization of previously strained dunite implies quite a different history of formation and intrusion from the essentially igneous one favoured by Challis and Lauder (Lauder, 1965, p. 499; Challis and Lauder, 1966; Challis, 1967, p. 202). In combination with the demonstration of the kink nature of the strain bands by Raleigh (1968), and the common preferred orientation in the mosaic grains, the evidence of deformation and recrystallization suggests a solid state, essentially metamorphic mode of intrusion, as has been demonstrated for the Twin Sisters mass (Ragan, 1967).

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