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# Host control of recrystallized quartz grains

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SUMMARY. The results of a petrofabric study on recrystallization of quartz in nature are presented and compared with recent experimental work. The orientations of newly recrystallized quartz grains are shown to be dependent on the orientation of host grains from or in which they grew. The results are compatible with the experiments of Hobbs (1968). The orientation of new grains appears to be unrelated to stress.

THE experimental work of Hobbs (1968) on the recrystallization of single crystals of quartz showed that the orientation of newly recrystallized grains was controlled fundamentally by the orientation of the host grain from or in which they grew. This observation contradicts previous theory (Kamb, 1959, 1961; Brace, 1960), experiment (Griggs *et al.*, 1960), and field studies (Sylvester and Christie, 1968), which suggested that the orientation of newly recrystallized grains and any resulting preferred orientation was controlled by stress. These studies largely ignored the long recognized phenomenon of host-controlled recrystallization in metals (Barrett and Massalski, 1966).

In order to verify that a host control operates in the orientation of newly recrystallized quartz grains in nature and hence contributes to the development of natural preferred orientations, a study of quartz recrystallization was undertaken on a suite of retrograde rocks from the Broken Hill area of western New South Wales, Australia.

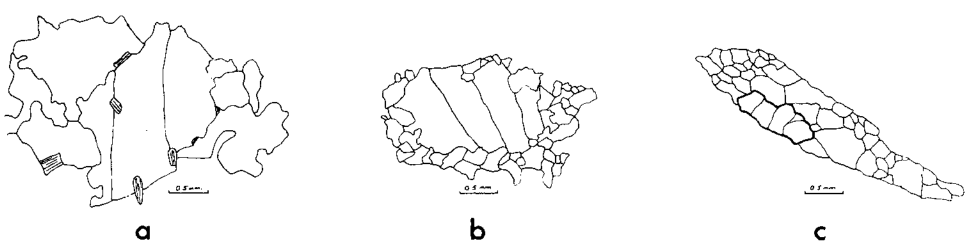


FIG. 1. Gradation in quartz microstructure from unaltered Potosi gneiss (*a*), through recrystallized grains outside the schist zones (*b*), to elongate recrystallized grain groups in the retrograde schists proper (*c*).

These rocks occur in and near retrograde schist-zones, described in detail by Vernon (1969), Hobbs *et al.* (1968), and Vernon and Ransom (1970), which are narrow (from a few millimetres to over 100 m in width), conjugate, planar zones (similar to mylonite zones) transecting the high-grade metamorphic rocks of the region and locally reducing the grade of metamorphism from granulite to amphibolite facies. The specimens studied were collected from a quarry in Eyre Street, Broken Hill, where there outcrops

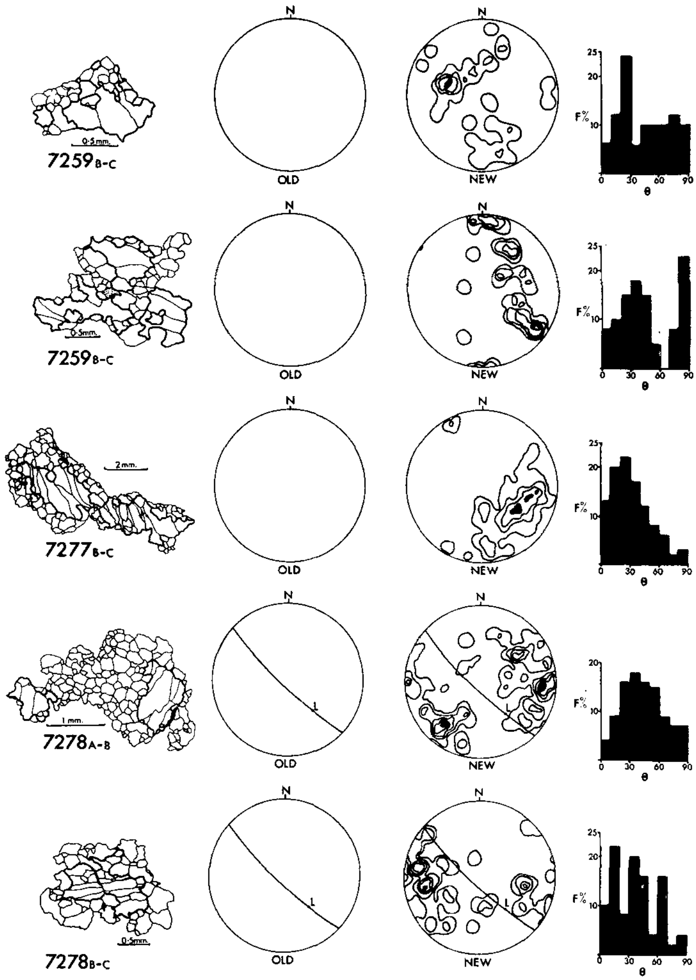


FIG. 2. Petrofabric data of recrystallized quartz grain groups from outside the schist-zones, showing: 1, the aggregate shape; 2, the orientation of the host (or old) grain; 3, the orientation of newly recrystallized grains; 4, the frequency of host/new-grain *c*-axis angles ($\theta$). The specimen numbers are those of the Department of Geophysics and Geochemistry, Australian National University collection. Contour (Schmidt's method) and other data are: 7259 B–C, old, 18 subgrains measured, new, 36 grains; 1, 4, 8, 12° to contours, max. 17·6%. 7259 B–C, old, 12 subgrains measured, new, 36 grains; 1, 4, 8, 12, 16% contours, max. 16·7%. 7277 B–C, old, 8 subgrains measured, new, 145 grains; 1, 3, 6, 9% contours, max. 11·0%. 7278 A–B, old, 5 subgrains measured, new, 172 grains; 1, 2, 3, 4, 5% contours, max. 6·4%. 7278 B–C, old, 6 subgrains measured, new, 51 grains; 1, 3, 6, 8, 12% contours, max. 13·7%.

a relatively homogeneous quartz–biotite–potash feldspar–plagioclase–garnet gneiss, known locally as 'Potosi' gneiss. A number of prominent retrograde schist-zones occur in the quarry face as thin (less than 1 m) vertically oriented cross-cutting structures. All mesoscopic variations between the coarsely crystalline gneiss and the finely foliated and lineated retrograde schist may be observed in the quarry face. Similarly, all microstructural variations may be observed in thin-section. It is therefore possible to trace the microstructural changes exhibited by quartz during retrogression, and hence to study the orientation of the newly recrystallized grains thus defined relative to their hosts. The microstructural and microfabric evolution of the schist-zones is described

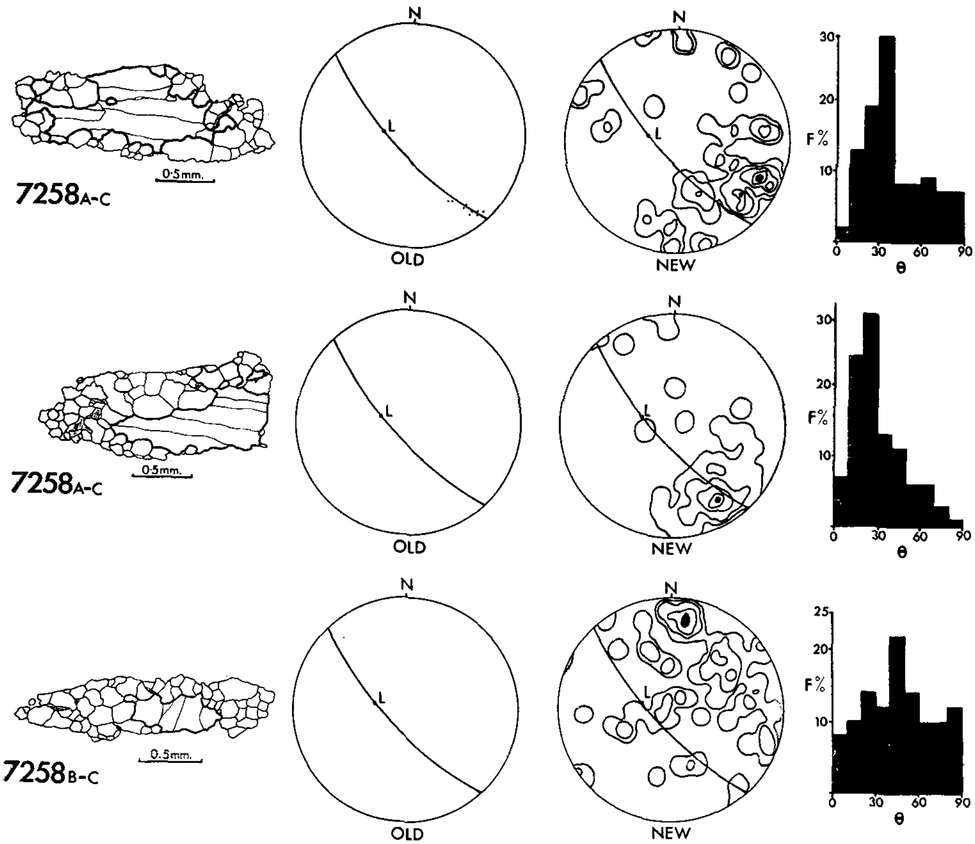


FIG. 3. As fig. 2, but for grain groups from within the schist zones. 7258 A–C, old, 11 subgrains measured; new, 54 grains; 1, 3, 6, 9, 12% contours, max. 14·8%. 7258 A–C, old, 9 subgrains measured, new, 67 grains; 1, 5, 15, 20% contours, max. 20·9%. 7258 B–C, old, 3 subgrains measured, new, 58 grains; 1, 3, 6, 9% contours, max. 10·8%.

elsewhere (Ransom, 1969), but fig. 1 shows the gradation in microstructure of quartz from that occurring in this high-grade gneiss to that occurring in the retrograde schist.

Individual grain groups of the type exhibited by figs. 1*b* and 1*c* were selected for measurement using standard optical techniques. The results are shown in figs. 2 and 3, where the shape of the selected grain groups, the orientations of the old and new grains, and the per cent frequency of the angle between the old and new grains is shown. Fig. 2 shows grain groups outside the schist-zones and fig. 3 shows grain groups taken from within the schist-zones. Clearly, the *c*-axes of most new grains fall between 20° and 40° to the orientation of their host. This tendency is further illustrated by the frequency diagram in fig. 4 where all angles between hosts and newly recrystallized grains are incorporated.

If the shapes of the frequency diagrams of fig. 2 and 3 are compared with those obtained experimentally by Hobbs (1966, fig. 14), it is seen that those of fig. 2 are

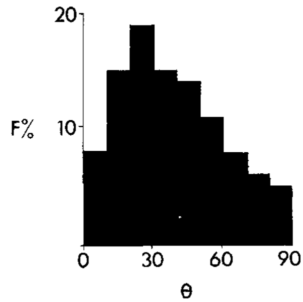


FIG. 4. Total per cent frequency diagram of angles between *c*-axes of all host and new grains measured.

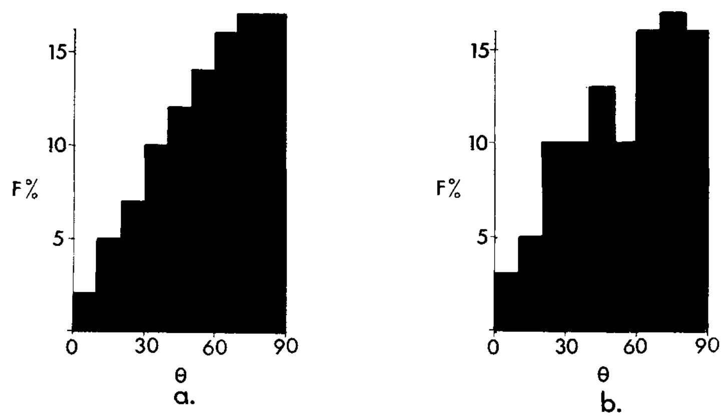


FIG. 5. (*a*) Per cent frequency distribution of angles between a single line and a random set of lines emanating from a point. (*b*) Per cent frequency distribution of angles between the *c*-axes of recrystallized quartz grains and the obtuse bisectrix of the commonest retrograde schist-zone orientations at Broken Hill.

similar to Hobbs syntectonic experiments and those of fig. 3 are similar to the annealing and stress annealing experiments. Both sets of data exhibit maxima at 20–40° to the orientations of the respective host grains. There seems to be good agreement between the experiments and the occurrence in nature.

Statistically, if lines emanating from an origin intersect a concentric sphere, the random directions are represented at random on the surface of a sphere. If $\theta$ is the distance from a fixed pole on a sphere, it can be shown that the chance of a point falling within the zone $\theta$ and $(\theta+\delta\theta)$ of a hemisphere is $\cos\theta$—$\cos(\theta+\delta\theta)$ (Plummer, 1940, p. 63). If $\delta\theta$ is equal to 10°, then for 100 random points a frequency diagram will have the random distribution shown in fig. 5*a*. A random population of any number expressed as a frequency per cent would approximate this distribution. The frequency diagrams in figs. 2, 3, and 4 do not exhibit any such tendency towards randomness, hence the measured frequency maxima at 30–40° are both real and significant.

In order to examine the dependence of the orientation of newly recrystallized grains to influences outside the recrystallizing grain group such as stress, the angle between the *c*-axis of each new quartz grain and a line defined by the obtuse bisector of the most prominent (i.e. conjugate) schist-zone orientations at Broken Hill (Hobbs, 1966) was measured. The results are shown in fig. 5*b*. There is an obvious resemblance between the measured distribution and the theoretical random distribution of fig. 5*b*. The orientation of the new grains is therefore random with respect to the line defined and therefore random with respect to *any* line. Assuming stress is homogeneous or even statistically homogeneous over the small area of the outcrop studied, it may be represented by such a line as defined above and two others normal to it. If this condition operates in the outcrop studied, then the orientation of new grains is independent of the orientation of stress.

The data presented generally confirm the experimental observations of Hobbs (1968), and show that host control of newly recrystallized quartz grains operates in nature as well as experiment. As such, host control must be considered in the dynamic interpretation of all quartz fabrics where recrystallization can be demonstrated. The data also show that, for the rocks studied at least, the orientation of new grains is likely to be unrelated to any homogeneous or statistically homogeneous stress influencing the system on a mesoscopic scale.

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