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The role of Dauphiné twinning in the initiation of dynamic recrystallization within quartz porphyroclasts

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In order to investigate the initiation of dynamic recrystallization in quartz, microstructures in greenschist facies granitoid protomylonites and mylonites (Austroalpine Arolla unit, North-Western Italian Alps) have been investigated in detail by electron backscatter diffraction (EBSD). In both protomylonites and mylonites, quartz form porphyroclasts dispersed within a mica-rich weak aggregate and underwent a dominant flattening strain. Here, we restrict our investigations on porphyroclasts with their c-axis oriented at a small synthetic angle with respect to the normal to foliation (XY plane of bulk strain).

Within protomylonites, quartz porphyroclasts of an estimated longitudinal strain of 50% contain a pervasive network of Dauphiné twins. This network is evident from the characteristic rotation of 60° around the c-axis, from the orientation contrast images and from the hexagonal symmetry of the pole figures of the positive {r} and negative {z} rhombs. Dauphiné twins are most commonly elongated and wider than 10 microns but often irregular in shape and size. They typically occur in conjugate sets with intersection angles of 65-90° symmetrically arranged to Z-direction (i.e., normal to the foliation), suggesting mechanical twinning during deformation of the porphyroclasts.

Individual twins show extensive polygonization with a set of tilt and twist boundaries orthogonal to each other. Crystallographic relationships suggest slip on {r} and {z} planes along <a> axes. Subgrains are more intensely developed on one of the two twin sets. Incipient recrystallization to fine aggregates (10-50 microns, same as subgrain size) is strictly localized along the Dauphiné twins. The crystallographic preferred orientation of the recrystallized grains shows a clear host control exerted by the Dauphiné twin.

In mylonites twinning is less frequent within quartz porphyroclasts of in average 61% longitudinal strain. Here, twins typically occur as a single set of thin (20-50 microns thick at maximum) bands. Extensive formation of subgrains within the twin bands is still associated with slip along {r} <a> and {z} <a> slip systems and with the formation of both tilt- and twist boundaries. However, the porphyroclast outside the discrete twins, shows subgrain polygonization associated with prism <a> and basal <a> slip. Commonly, highly strained quartz porphyroclasts are cut by intracrystalline shear zones of recrystallized grains interpreted to exploit former Dauphiné twin bands. The c-axis orientation of these recrystallization aggregates includes one maximum inherited from the Dauphiné twin orientation and a second one orthogonal to the twin band boundary. This latter is consistent with basal slip during shearing along the twin band.

This study shows that mechanical Dauphiné twinning can be a common deformation feature within quartz porphyroclasts undergoing dominant coaxial strain. During further deformation Dauphiné twins play a significant role in (1) the selection of the active slip systems, (2) the localization of subgrain boundaries along specific twin bands, and, at higher strain, (3) the dynamic recrystallization into intracrystalline shear bands along twin bands.