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Subgrain boundaries and slip systems in quartz

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At elevated temperatures, quartz usually deforms by dislocation glide and dislocation creep. Textures (crystallographic preferred orientations) and microstructures are commonly used to infer the kinematics and physical conditions of deformation. However, it is debatable whether a given texture, represented by a pole figure, is universally indicative of a specific deformation temperature or recrystallization mechanism or e.g. is rather related to strain.

Quartz veins in synkinematic, felsic dikes from the footwall of the Mohave Wash detachment fault in the Chemehuevi Mountains are studied by EBSD, CIP and universal stage. Mm-sized quartz grains are homogeneously stretched with aspect ratios of up to 30. Minor recrystallization takes place by subgrain rotation. Three different groups of highly stretched quartz grains can be defined: Grains with peripheral c-axes at a high angle to the foliation (Z-grains), grains with central c-axes perpendicular to the lineation (Y-grains) and grains with c-axes intermediately between the former two (O-grains). The three types of grains do not show a significant difference in their aspect ratios. Bulk pole figures show a kinked single c-axes girdle with a central maximum and an a-axes maximum parallel to the lineation.

Misorientation analysis and the orientation of subgrain boundaries are used to make inferences on slip systems. Z-grains are interpreted to be suitable for basal (c)<a>-slip, Y-grains for prism {m}<a>-slip, which is compatible with the bulk misorientation distribution function of entire grains. O-grains could be interpreted as suitably oriented for rhomb {r/z/pi/pi'}<a> slip, however, this is not supported by the bulk misorientation distribution function.
Individual subgrain boundaries in Y-grains and Z-grains expected for the 'easy' slip systems {m}<a> and (c)<a> with tilt character ({a} parallel boundaries with [c] or <m> misorientation axes, respectively), are limited to small (< 2°) misorientation angles. Subgrain boundaries with higher misorientation angles relate to variable slip systems, showing tilt, twist or mixed mode character. Many of those slip systems have a low Schmid factor. O-grains rarely show subgrain boundaries that can directly be related to rhomb<a> or rhomb<c±a>-slip. Most common subgrain boundaries are tilt {a}[c]-boundaries, tilt {a}<m>-boundaries or mixed mode boundaries, hence deformation is interpreted to occur mostly by combined {m}<a> and (c)<a>-slip rather than rhomb slip.

Based on the homogeneous microstructure without a low temperature overprint, it is inferred that deformation took place in a rather narrow temperature range. Grains deform homogeneously, independent on their orientation with different slip systems involved. A temperature effect on the activity of individual slip system is not recognizable.
Suitably oriented (c)<a> and {m}<a> slip systems seem to result in lattice bending rather than abundant subgrain boundaries. Subgrain boundaries related to other slip systems contribute to subgrain rotation and subsequent recrystallization but not essentially to stretching of grains and rather ensure strain compatibility.
The observations indicate that many prominent subgrain boundaries might not relate to the main strain producing slip system and grain orientation does not necessarily prescribe the involved slip systems.