Experimental Investigation of Lattice Preferred Orientation Development in Quartz Single Crystals Deformed Ductile with Added Water

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An experimental study has been carried out to investigate lattice preferred orientation (LPO) development in quartz single crystals. Cylindrical samples of natural single crystals of Brazilian quartz were axially deformed in a Griggs solid medium deformation apparatus in the ductile deformation field. The experiments were performed at a temperature of 800°C, a confining pressure of 1.2 GPa, strain rates in the range $0.7\text{-}1{\cdot}10^{-6}\ s^{-1}$, with ~1 vol% added water. First results are obtained on three crystals deformed in O^+ orientation (shortening direction *Z* at 45° to the c-axis and 45° to the a-axis) to bulk finite strains of 11 to 22%. The LPO was measured optically with a u-stage. Three different mechanisms of LPO development were observed:

1. *Reorientation by glide along deformation lamellae* - In areas deformed to low finite strains (typically less than ~10%), the c-axis rotated up to an amount of ~20° towards *Z*. This occured in areas where abundant subbasal deformation lamellae developed. The areas are diffuse and elongated approximately parallel to the c-axis. Rotation took place by glide along the subbasal lamellae.

2. *Reorientation by sliding of fragments along fractures* - At higher strains, zones of new grains and subgrains (50-500 μm) locally developed. These (sub)grains are interpreted as being fracture-fragments developed by cataclastic deformation. They are mostly elongated parallel to *Z*, parallel to the dominant fracture orientation. The *c*-axes rotated in various directions away from the original orientation, in directions distinctly different from the above lamellar glide, towards and also away from *Z*. Reorientation must have been controlled by the local orientation of the fractures.

3. *Reorientation by nucleation of small new grains* - Within the areas of presumed cataclastic deformation, small, new, sub-euhedral grains (40-80 μm) grew locally. The c-axes of these small grains are almost exclusively oriented at a high angle (~60 to 90°) to the c-axes orientation of the surrounding (sub)grains. These grains must have nucleated in this orientation and grown by grain boundary migration. Why new grains develop in this specific orientation is not well understood so far. An EBSD study is planned to further research this phenomenon.

The present results illustrate how various reorientation processes may act together to produce a final LPO in quartz in experiments and, maybe, in nature.