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Rapid development of crystallographic preferred orientation compared to sluggish development of deformation microstructure in natural quartz veins during progressive simple shear at T>500°C

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The microstructure and crystallographic preferred orientation (CPO) of quartz was quantified in natural monomineralic tabular veins deformed at ca. 500°C over a range of shear strains (gamma) from zero to about 15. The veins filled a set of early postmagmatic joints within the Adamello tonalite (Southern Alps, Italy) and localized homogeneous simple shear during the high temperature stages of pluton cooling. The shear strain of deformed veins was determined by the inclination of the internal foliation of the vein, assuming simple shear parallel to the vein boundary, and by the offset of aplite dykes crosscut by the veins. Depending on the intensity of deformation, microstructure and grain size, the analyzed veins can be categorized into weakly deformed (WDV; gamma < 1), moderately deformed (MDV; 2 < gamma < 3) and strongly deformed (SDV; gamma > 4). The WDV consist of large (mm to cm in size) preferentially elongated (and stretched) crystals with the long axes oriented at a high angle (35-45°) to the vein boundary (XY plane) with a consistent inclination relative to the shear sense. Most crystals show extensive coarse (100's microns) polygonization with chessboard-like patters, grain boundary bulging and incipient fine recrystallization along grain boundaries and internal discrete shear bands. Some deformed portions of the crystals show strongly sutured grain boundaries. The MDV show a well developed oblique foliation and a coarse grain size recognizable in hand specimens. The shape of grains is highly serrated to skeletal in some cases. Thin sections reveal that in many cases different grains belong to a common parent grain. This implies a complex interlobated grain structure in 3D. Some of these parent grains are stretched to ribbons extending for the whole length of the thin section, especially crystals with a c-axis orientation close to the Y direction. The serrated outline of the grains is partly determined, at a fine scale, by a rim of equant polygonal small new grains that form a small (< 10%) volume fraction of the quartzite. The SDV consist of completely recrystallized aggregates of new quartz grains of mean grain size of 35-40 microns without any systematic variation with increasing shear strain. They show extinction banding outlining the foliation, which reflects the recrystallization of ribbons with original different crystallographic orientation. The extensive recrystallization of quartzite to fine grains occurs abruptly in the gamma range between 3 and 4.

X-ray texture goniometry (using a polycapillarity parallel-beam optic system with a primary beam size of 7 mm) and computer-integrated polarization microscopy (CIP) were used to determine the CPO. Both methods allow the investigation of large sample areas (up to several square cm) and therefore provide a good data statistics also for the coarse grained samples. A strong CPO is achieved at relatively low strain (about gamma = 2) in WDV, i.e. well before complete recrystallization to fine aggregates and the development of a steady state microstructure. It is characterized by a strong c-axis Y-maximum and a distinct <a> axis maximum at the periphery of the pole figure, at a small synthetic angle to the stretching lineation. The strong CPO in MDV is mainly accomplished by competitive growth due to extensive fast grain boundary migration of grains well oriented for prism <a> slip. This type of CPO and the synkinematic assemblage of tonalite mylonites (including stable biotite and An(40)-plagioclase) constrain the temperature of deformation to be > 500°C.