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Microstructures in quartz veins from the Rochechouart impact structure and St. Paul de la Roche, France – high stress behaviour of quartz during rapid loading

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Shock effects in quartz veins from the Rochechouart impact structure, France, and quartz microstructures indicative of high stress tectonic deformation in veins from St. Paul de la Roche, ∼30 km SW outside the impact structure, are compared and contrasted.

Cataclastic zones occur in recrystallized vein quartz located ∼5 km NE of the assumed centre within the Rochechouart impact structure. They show a marked shear offset and comprise small grains with a diameter of 7-40 μm. Restricted to larger old grains within or next to these cataclastic zones, quartz can contain planar deformation features (PDFs) parallel to the basal plane. Transmission electron microscopy (TEM) reveals that these features represent mechanical Brazil twins in the (0001) plane. In nature, these mechanical twins are exclusively known from impact structures. They have, however, been experimentally produced at high shear stress experiments at static pressures. In contrast, they are not known from high pressure shock experiments. PDFs parallel to rhombohedral planes of quartz that are diagnostic for high shock pressures in nature and experiment do not occur in the described quartz veins, whereas they are frequent in impact breccias and target rocks closer to the centre of the crater. The absence of rhombohedral PDFs and the occurrence of basal PDFs that represent mechanical Brazil twins imply relatively low dynamic shock pressures ($<$ 8 GPa) and a high shock-induced differential stress (∼4 GPa).

Vein quartz from St. Paul de la Roche ∼30 km SW outside the Rochechouart impact structure shows a heterogeneous microstructure with low angle grain boundaries, deformation bands, striking wavy deformation lamellae and strings of recrystallised grains. Curved low angle grain boundaries ($\sim 2^\circ$) are bounding irregular domains of a few hundred μm in diameter. Wavy deformation lamellae are common within these large subgrains and the misorientation along these is $<2^\circ$. In TEM they are represented by diffuse dislocation walls and a relatively homogeneously high dislocation density ($\sim 10^{13} m^2$). Subparallel bands of several hundred μm spacing are characterised by smaller sized subgrains ($\sim$50-100 μm) that show an increased misorientation of up to 8˚. At a high angle to these, subparallel deformation bands occur that are characterised by a misorientation of up to 10˚. Along very straight strings of recrystallised (6-100 μm) grains with a random crystallographic orientation occur. This microfabric contrasts clearly from the vein quartz within the Rochechouart impact structure. However, it records non-steady state glide-controlled deformation with restricted dislocation climb at high differential stress and lower loading rates compared to shock. Such microstructures are known from deformation related to stress redistribution during a major earthquake in the upper crust.

Comparison of shock effects in target rocks and high stress tectonic microstructures yields information on the behaviour of quartz during rapid loading.