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Deformation and ultrafine recrystallization of quartz in pseudotachylyte-bearing brittle faults: A matter of a few seconds

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Tectonic pseudotachylytes, i.e. quenched friction-induced silicate melts, record coseismic slip along faults and are mainly reported from the brittle crust in association with cataclasites. The temporal and spatial association of fine-grained quartz with pseudotachylytes have been described within the literature for several locations and seems to be an important feature characteristic for seismic processes.
In this study, we document the occurrence of recrystallization of quartz to ultrafine-grained (grain size 1-2 μm) aggregates along microshear zones (50-150 μm thick) in the host rock adjacent to pseudotachylytes from two different faults within quartzite (Schneeberg Normal Fault Zone, Eastern Alps), and tonalite (Adamello fault, Southern Alps). The transition from the host quartz to microshear zone interior includes: (i) formation of high dislocation densities; (ii) fine (0.3-0.5 μm) polygonization to subgrains defined by disordered to well-ordered dislocation walls; (iii) development of a mosaic aggregate of dislocation-free new grains. The crystallographic preferred orientation (CPO) of quartz towards the microshear zone shows a progressive misorientation from the host grain, by subgrain rotation recrystallization, to a nearly random CPO possibly related to grain boundary sliding. Thus these ultrafine quartz aggregates appear to be typically associated with pseudotachylytes in nature. Microshear zones localized on precursory fractures developed during the stages of earthquake rupture propagation and the very initial stages of fault slip (Bestmann et al., 2011).
Based on thermal models we suggest that crystal plastic deformation of quartz accompanied by dramatic grain size refinement occurs during seismic faulting at the base of the brittle crust as a result of the high temperature transients (> 800°C) related to frictional heating in the host rock selvages of the slip surface. These localised high deformation temperatures made possible that the process of recrystallization, including recovery processes, could occur in a time lapse of a few tens of seconds.

Bestmann, M., Pennacchioni, G., Frank, G., Göken, M., de Wall, H., 2011. Pseudotachylyte in muscovite-bearing quartzite: coseismic friction-induced melting and plastic deformation of quartz. Journal of Structural Geology 33, 169-186.