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High-stress crystal plasticity of amphibole and quartz in pseudotachylyte-bearing gneisses and dislocation creep in concordant quartz-rich layers from the Silvretta basal thrust (Austria)

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Pseudotachylyte-bearing amphibole-rich gneisses with concordant quartz-rich layers from the base of the Silvretta nappe, Austria, are analyzed by polarized light microscopy, scanning electron microscopy and electron back scattered diffraction. Amphibole grains show microfractures, undulatory extinction, deformation lamellae, kink bands, mechanical twins and locally recrystallized grains restricted to sites of high strain, e.g. along microshear zones and twin boundaries. The twins are characterized by a twin plane parallel to (-101), a rotation axis parallel to [101] and a misorientation angle of 178°. The (-101) amphibole twins document the high differential stresses during crystal plasticity coeval with pseudotachylyte formation, given their high critical resolved shear stress of 200 MPa. Directly at the contact to twinned amphibole within the gneisses, quartz grains commonly show subbasal deformation lamellae, short-wavelength undulatory extinction and cleavage cracks mostly parallel to {10-11} rhombohedral planes that are decorated by recrystallized grains with a diameter of < 10 µm. The small recrystallized grains show a crystallographic preferred orientation (CPO) that is controlled by the orientation of the host grains. This quartz microstructure consistently indicates high-stress crystal plasticity of quartz concurrent with high-stress crystal plasticity of amphibole and pseudotachylyte formation.

Quartz-rich layers (>90% quartz) concordant to the foliation of the gneisses commonly show evidence of dynamic recrystallization in the regime of dislocation creep. The recrystallized grain microstructure is mostly homogenous without a gradient towards the lithological contact to the amphibole-rich gneisses. Locally, however, a gradient of decreasing strain towards the contact can be observed as indicated by a decreasing number of recrystallized grains. Close to the contact, quartz grains are coarse with long axes of a few mm. A core-and-mantle structure, where recrystallized grains surround a few hundred µm wide and mm-long porphyroclasts, is occurring in transition towards an almost completely recrystallized microstructure. The recrystallized grains show a CPO indicating rhombohedral <a> dislocation glide. Recrystallized grains are isometric and subgrains in porphyroclasts are of similar shape and size, indicating dynamic subgrain rotation recrystallization. Stresses on the order of hundred MPa are suggested by the diameter of recrystallized grains of in average about 10 µm. Locally, the recrystallized quartz aggregate is affected by subsequent low-temperature plasticity, as indicated by shear fractures offsetting the

recrystallized microstructure. The missing or decreasing strain gradients of dislocation creep within the quartz-rich layers towards the amphibole-rich gneisses indicate that dislocation creep in the quartz-rich layers cannot be responsible for transferring high stresses required for high-stress crystal-plasticity of quartz and amphibole as well as pseudotachylyte-formation and suggest that dislocation creep of quartz represents an independent earlier stage of deformation.