Geophysical Research Abstracts
Vol. 21, EGU2019-5275, 2019
EGU General Assembly 2019

Viscous creep drives brittle failure at the base of the seismogenic zone

Luca Menegon (1) and Ake Fagereng (2)

(1) Plymouth University, School of Geography, Earth and Environmental Sciences, Plymouth, United Kingdom (luca.menegon@plymouth.ac.uk), (2) Cardiff University, School of Earth and Ocean Sciences, Cardiff , United Kingdom (fagerenga@cardiff.ac.uk)

Aseismic creep is commonly accompanied, initiated, or followed by transient seismic deformation. Various models have been suggested for the interplay between seismic and aseismic deformation on a single structure, including spatially heterogeneous composition and viscosity, fluid pressure, or deforming thickness. Models also vary between seismic deformation triggered by creep, and creep triggered by seismic slip. Here, we address this problem by detailed structural investigation of a brittle-viscous shear zone at Sagelvvatn, Northern Norway. The shear zone occurs along a thrust zone that accommodated the top-to-ESE nappe emplacement in the Upper Allochthon of the Norwegian Caledonides.

The shear zone is dominantly ductile, but locally sigmoidal quartz veins crosscut the subhorizontal mylonitic fabric at a high angle. The veins are only observed within a relatively coarse-grained mylonitic metaconglomerate horizon sandwiched between mica schists. The veins have tips oriented at approximately 45° to the shear zone margins, and are rotated and folded with the sense of shear of the mylonite. Fold hinge lines in the veins and stretching lineations in the mylonite are approximately perpendicular. Vein quartz long axes are subparallel to the stretching lineation in the mylonite, and at a high (70 – 80°) angle to the vein margins. The veins have a layered internal structure with thin chlorite layers, subparallel to the vein margins, separating quartz layers. Chlorite thermometry indicates that vein emplacement and mylonitisation occurred at ca. 400°C.

The mylonitic metaconglomerate consists of monomineralic quartz pebbles embedded in a quartz + carbonates recrystallized cement. The pebbles are highly elongated and lack fractures or boudinage. Quartz microstructure is consistent with dynamic recrystallization by subgrain rotation and limited grain boundary migration. The average recrystallized grain size of quartz is 110 μm, which indicates differential stresses around 20 MPa during mylonitic flow.

The veins reflect the same kinematics as the shear zone, and are therefore interpreted as triggered and controlled by the viscous flow within the mylonite. Thus, we suggest a model where brittle failure arises spontaneously within a creeping shear zone. Progressive shear strain within a stretching shear zone dynamically increases pressure within the deforming zone, requiring expulsion of fluids from within the shear zone. In fine grained shear zones, a dynamic porosity may be maintained by creep cavitation, but the coarse grain size in the Sagelvvatn metaconglomerate does not allow this. Fluid pressure can also not be released by diffusion out of the shear zone as the metaconglomerate is flanked by low permeability phyllosilicate reach horizons. Instead, the increased fluid pressure leads to episodic fracturing as a direct consequence of creep, when the hydrofracture criterion is reached. These fractures accompany creep, and their geophysical expression will likely depend on the stiffness of the shear zone relative to the surrounding elastic materials.