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Localised slip controlled by dehydration embrittlement of partly serpentinised dunites, Leka Ophiolite Complex, Norway

Kristina G. Dunkel, Håkon Austrheim, Benoit Cordonnier, and Bjørn Jamtveit
University of Oslo, Physics of Geological Processes, Oslo, Norway (kristina.dunkel@geo.uio.no)

Dehydration of serpentinised ultramafic rocks can increase the pore fluid pressure and induce brittle failure; however the extents of strain localisation and unstable frictional sliding are still under debate. Microstructural and mineralogical evidence from dunites of the Leka Ophiolite Complex in the Central Norwegian Caledonides demonstrates that prograde metamorphism of serpentinite veins led to local fluid production and to the growth of large-grained olivine rich in magnetite inclusions. The epitaxial growth of comparatively Fe-poor prograde olivine on Fe-richer relics of primary olivine caused a high variability in Fe-content, even within single crystals. On a larger scale, the average Fe-content of olivine rises towards the vein edges, which reflects a decrease in the degree of initial serpentinisation towards the host rock. The former distribution of serpentine strongly influenced the mechanical response of the rock to the fluid production during deserpentinisation: The faulting caused by the associated dehydration embrittlement occurred along highly localized slip planes in the centres of the meta-serpentinite veins. Around these slip planes, the prograde olivine experienced significant grain size reduction, but very limited shear strain. The strain concentration on narrow faults, also documented by a sharp offset of chromite layers, and the brittle deformation of the surrounding olivine suggest unstable frictional sliding rather than slower creep.
This natural example of deserpentinisation-induced embrittlement illustrates that structural heterogeneities in the form of serpentinite veins have first-order controls on strain localisation and frictional sliding. While strain may be distributed during dehydration of a homogeneous serpentinite, as has been observed in recent experimental studies, it may become strongly localised in a heterogeneous rock volume where fluid pressure is locally increased along pre-existing veins. As most of the oceanic lithosphere is incompletely serpentinised, heterogeneities represented by a non-uniform distribution of serpentinite are likely to occur and may increase the probability that dehydration embrittlement triggers earthquakes in subducting slabs.