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High strain rates and low viscosities in mylonitised pseudotachylytes – a lower crustal record of postseismic creep?

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In dry and strong feldspar-rich lower crust, deformation can be highly localised within narrow shear zones cutting through otherwise undeformed rock. Mylonitic shear zones near Nusfjord, Lofoten, northern Norway, localise on precursor structures within a coarse-grained, anhydrous anorthosite body. Several of these precursor structures were pseudotachylyte-bearing fault planes. Individual pseudotachylytes may induce highly localised shearing, where the vein is internally sheared but the brittle fault morphology is preserved, or, where greater volumes of pseudotachylytes are present, a wider shear zone may develop encompassing the whole suite of veins. These latter structures appear to characterise the dominant shear zones within the Nusfjord area.

Scanning electron microscopy (SEM) and electron backscattered diffraction (EBSD) analysis of sheared pseudotachylytes reveals a fine-grained matrix that likely facilitates grain-size sensitive deformation mechanisms. Recrystallised quartz ribbons caught up within the vein and in the vein margins allow the application of flow laws and viscosity calculations. Strain rates calculated for the Nusfjord mylonitised pseudotachylytes are > 10^{-10} s^{-1}, orders of magnitude faster than typical geological creep rates, and have low viscosities which at $\sim 10^{16}$ Pa.s are comparable with geodetic observations of postseismic relaxation. Hence, these samples may record an entire earthquake cycle, from coseismic frictional melting through immediate recrystallisation under elevated postseismic strain rates, towards long-term ductile creep. An inherent challenge in this geological approach is the upscaling of quantitative microstructural results for comparison with the spatial scale of geodetic observations – models attempting to bridge this scale gap suggest that, despite their limited thickness, recrystallised pseudotachylytes may accommodate a large proportion of post- and inter-seismic deformation within the shear zone. These rheological models are important for understanding the ability of lower crustal shear zones to support cyclical viscous and frictional behaviour.