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Deformation of the Southern Troodos Transform Fault Zone, Cyprus: Implications for the seismic behaviour of oceanic transform faults

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Oceanic transform faults are deficient in seismicity relative to comparable-sized fault zones in other tectonic environments and, moreover, display enigmatic variations in along-strike and down-dip seismic behaviour. Whereas the base of the seismogenic zone is often explained as being controlled by a thermally-dependent frictional-viscous transition in olivine, a thermal control alone cannot explain the full distribution of seismicity at oceanic transform faults. For example, the predominance of creep at depths where rocks of mafic to ultramafic compositions are expected to slip seismically needs an alternative explanation.

Here, we present observations from a detailed geological investigation of the Southern Troodos Transform Fault Zone (STTFZ), an exhumed >5 km wide ocean floor fault zone preserved within the Troodos ophiolite of Cyprus. The STTFZ allows direct observation of structures preserved in entire sections through both mafic crust and serpentinised lithospheric mantle. We are working to decipher its ocean-floor deformation mechanisms, with the aim of providing direct geological constraints on generic transform fault seismic styles to address the problems outlined above.

Geological mapping of the STTFZ at regional to outcrop scale allows us to demonstrate heterogeneous rheological behaviour, with contrasting brittle-ductile deformation throughout all stratigraphic levels of the ophiolite. Breccias and cataclasites are dominant fault rocks in the crustal section. Deformation in the serpentinised mantle is largely accommodated by low-temperature serpentinite shear zones (SSZ), displaying mixed continuous-discontinuous deformation and complex internal geometries.

The range of brittle and ductile deformation structures observed in the STTFZ across a range of scales from detailed geological mapping to optical microscope and SEM observations show that the dominant deformation mechanism varied in time and space. Fracture and frictional sliding can explain brittle behaviour in the SDC and SSZ; however, in contrast, dissolution-precipitation processes are likely foliation-forming mechanisms in the serpentine matrix of the SSZ. We hypothesise, from geological observations in the STTFZ, that its seismic behaviour as an active oceanic transform fault was characterised by: (1) crustal faults with variable frictional properties depending on fault zone damage, and (2) a partially-coupled serpentinised mantle with low-temperature ductile deformation and aseismic creep.