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Anhydrite deformation and microstructures in the oceanic lower crust: an insight from Samail ophiolite core, Wadi Gideah GT1 Borehole.

Elisabetta Mariani (1), Laura Crispini (2), Damon Teagle (3), and the Oman Drilling Project Science Party

(1) University of Liverpool, School of Environmental Sciences, Liverpool, United Kingdom (mariani@liverpool.ac.uk), (2) Università degli Studi di Genova, Dipartimento di Scienze della terra, dell'ambiente e della vita, Italy (laura.crispini@unige.it), (3) University of Southampton, School of Ocean and Earth Science, Southampton, United Kingdom (Damon.Teagle@southampton.ac.uk)

Anhydrite is one of the weakest minerals in large scale fault zones. Its weak rheology means that deformation is likely to localise along anhydrite-rich layers. Thus the study of anhydrite microstructures in these layers provides important clues on the deformation history of fault zones.

The presence of anhydrite in oceanic crust environments is significant because this mineral is likely to act as a sink for sulphur. Thus understanding the mechanisms of precipitation and deformation of anhydrite and their timing in these environments can provide new insight into the sulphur cycle on Earth.

Notwithstanding its importance, the occurrence of anhydrite in the oceanic lower crust is poorly documented for two key reasons: 1) Sampling is limited to coring via Ocean Drilling Programme (ODP) initiatives and to those localities where the oceanic crust may be exposed on Earth. 2) Anhydrite is likely to form in fault zones where it can precipitate from circulating hot fluids. These are narrow zones of localised deformation and may be naturally under-sampled.

The Wadi Gideah GT1 borehole cored through a hydrothermal fault system that cuts through the layered gabbro of the oceanic lower crust. Fault rocks are altered to greenschist and prehnite-pumpellyte facies and acted as conduits for the circulation of hot hydrothermal fluids. Here anhydrite is found in deformed veins ranging from <1 mm to several cm thick, in association with augite, chlorite, prehnite, epidote and minor quartz. GT1 samples therefore represent an excellent, continuous and well preserved section, unaffected by present day surface weathering, to study the history and timing of anhydrite precipitation and deformation.

Anhydrite microstructures are analysed quantitatively using optical microscopy and EBSD. In GT1 fault rocks anhydrite is associated with prehnite in deformed veins that show a pervasive layering, defined by grainsize variations and prehnite bands. Anhydrite grain size distribution is bimodal and large grains and fragmented grains relicts (>1 mm diameter) are contained within a fine-grained matrix ($\sim$10 micron average grain diameter). Pervasive fracturing and grain comminution clearly indicate the activity of brittle deformation processes. This is supported by evidence from EBSD data that fabrics in the fine-grained matrix are inherited from the large anhydrite parent grains. However there is also evidence for viscous deformation of the anhydrite. This is provided by the high lattice distortions measured in the parent grains and by the strong CPO measured in both large and fine-grained anhydrite. {011} twinning is also observed in the larger grains. The pronounced [001] clustering at high angle to the shear plane suggests that (001) is the slip plane favoured for dislocation glide. The matrix is fully compacted and sealed. This might have been aided by some degree of recrystallization. Further analyses are necessary to establish whether dissolution-precipitation processes played a role in the deformation.

Anhydrite microstructures indicate that the hydrothermal fault system studied was active and fragmentation of large anhydrite grains might have happened by pulverisation during earthquake processes. Grain size reduction and deformation by brittle-viscous mechanisms suggest that the rock aggregate is likely to have accommodated fault creep during interseismic periods.