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Major shear zone and processes involved in exhumation and extension on S-Kythnos

I. Lenauer, G. Laner, B. Grasemann, and C. Iglseder

University of Vienna, Earth Sciences, Geodynamics and Sedimentology, Vienna, Austria (iris.lenauer@univie.ac.at)

The Western Cycladic island of Kythnos lies in the Aegean Sea and is composed of metamorphic rocks of the Attic Cycladic Crystalline, where ongoing extensional tectonics has led to exhumation of high-grade metamorphic rocks. Extension and thus exhumation localized at major shear zones found throughout the Aegean Sea. While islands of the Northern and Eastern Cyclades show crustal-scale detachments along low-angle normal faults with N- to NE-directed shear sense, the Western Cyclades show S- to SW-directed sense of shear.

On Kythnos, widespread SSW-directed shear sense can be observed in massive greenschist and marble layers. However, deformation is especially pronounced on a layer of extremely fine-grained ultramylonitic marble and a coexisting meter-scale cataclasite. The ultramylonite crops out on the southern tip of Kythnos island and dips southwestward at various angles. Due to extension-perpendicular shortening, the $\sim$5 m massive ultramylonite horizon appears buckled and internally folded. Within the ultramylonite shear zone, significant grain size reduction can be observed. The extreme thinning and mylonitic foliation point to large displacement values involving high shear strain. The grain size reduction of the ultramylonitic marble and the partially rounded components in the cataclasite may have provided the means for reducing the apparent fault friction, allowing movement along planes at a lower angle than mechanically predicted. Additionally, fluid activity may have been an important factor involved in friction reduction. Isotope studies of the ultramylonitic marble and associated calcite veins show interactions between rock fractures creating fluid paths and the effect of fluids on fracturing mechanisms. Furthermore, as low- and high-angle faults were active contemporaneously, fluid flow channeling along the strong foliation und thus increase in permeability may have led to additional reduction of friction in the ultramylonitic layers.

Further exhumation led to extensional shearing migrating to higher crustal levels and to deformation being focused on a steep dipping layer of cataclastic to ultra-cataclastic material. A significant feature of the cataclasites is the occurrence of rounded marble components.

Quartzitic lithologies overlying the calcitic ultramylonite shear zone show various degrees of deformation from protocataclasites to statically recrystallized quartz-rich rocks. This implies that temperature during deformation allowed dynamic recrystallization of calcite, but not quartz grains, and thus led to strain localization in weaker marble layers.

The ductile to brittle shear zone gives evidence for movement along both low- and high-angle normal faults, which develop as ultramylonites and cataclasites, and depicts the evolution of the shear zone from the lower to the upper crust.