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Ductile to brittle progressive deformation within crustal-scale shear zones, Western Cyclades, Greece

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Intense seismicity and intensely developed active and ancient fault systems are common to the Aegean Region. New geological/structural investigations on Kea, in the Western Cyclades reveal a crustal-scale, detachment-type ductile shear zone probably formed during Miocene extension and thinning of the continental crust.

The area of interest, which lies in north-western Kea, comprises a large-scale detachment shear zone. A several meter thick cataclastic zone separates steeply dipping ankeritised dolomite in the hanging wall from folded (ultra-)mylonitic marbles in the footwall. The locally more than 10m thick brittle fault zone comprises numerous generations of cataclasites ranging from foliated protocataclasites with brittle/ductile overprint, incohesive coarse grained fault breccias and partly graphitic fine grained fault gouges. This brittle fault zone locally includes a 2 m thick serpentinite-talc zone, fractured boudin lenses of opalescent serpentine associated with partly ankeritised (mega-) boudins of Dolomites. In the northern part of the Kea this brittle fault zone can be mapped over several kilometres. The faults are dipping at low angle towards the NNW. Slickenlines on brittle faults show consistent NNE-SSW orientations. Shear sense indicators like scaly fabrics and Riedel geometries of secondary fractures consistently indicate south directed displacement of the hanging wall.

The footwall of the brittle fault zone consists of a several tens of meters thick ultra-mylonitic shear zone, mainly comprising marbles, phyllites, gneisses and quartzitic schists .The mylonites have a pronounced stretching lineation, which show a maximum dipping gently towards NNE parallel to the brittle kinematics. Countless textbook examples of a broad range of shear sense indicators (flanking structures, asymmetric boudinage, stable porphyroclasts with monoclinic symmetry, rotated and boudinaged veins) consistently indicate a south-directed, non-coaxial shearing. However, the most striking structural observation is the upright non-cylindrical folding of the mylonites with fold axes parallel to the stretching lineation. Shearing of these folds into tubular/sheath folds suggests that folding occurred during shearing due to shortening perpendicular to the stretching lineation. Partly folding of the structurally upper cataclastic zones suggest that this W-E shortening component accompanied deformation from ductile, brittle/ductile to brittle conditions.

Several generations of extension gashes filled with calcite, quartz and actinolite are widespread throughout the mylonitic rocks. Locally, some extension gashes with associated flanking folds are rotated into the shearing direction developing trains of elongated boudins. Quantitive kinematic flow analyses suggest an effective shear strain in the orders of several tens of gamma supporting the interpretation of a high-strain shear zone corroborating with the observation of sheath fold.

In summary, lithological and structural investigations on Kea indicate that the island is a further example of crustal scale shear zone. Preliminary observations suggest that the shear zone bends around the whole island forming a dome-shaped antiform. In analogy to Serifos, a metamorphic core complex to the S of Kea, we speculate that the mapped shear zone on Kea is part of an extensional S directed detachment system.