Quantitative kinematic flow analysis in an extensional crustal-scale shear zone regime (Kea, 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 investigation on the island of Kea (also known as Tzia), in the Western Cyclades reveal a probable crustal-scale, detachment type shear zone probably formed during Miocene extension and thinning of the continental crust.

Several generations of extension gashes filled with calcite, quartz and actinolite are widespread throughout the mylonitic rocks and gneiss. Locally situated in gneiss, some extension gashes with associated flanking folds are rotated into the shearing direction developing trains of elongated boudins over several meters. Quantitative kinematic flow analyses suggest a moderate finite shear strain for this area which is in contrast to the observation of sheath fold developed in the mylonitic marble. These sheath folds developed through co-eval NNE directed extensional shearing and W-E shortening that resulted in the unusual development of upright non-cylindrical folds whose axes have rotated into the finite stretching lineation, generating the rarely observed sheath fold that resembles a type 01 refold, probably require high strain to become amplified and so further support our interpretation of a high-strain shear zone.

The area of interest, which lies in north-western Kea, comprises a low angle shear zone where ductile to brittle progressive deformation can be observed. A several meter thick brittle cataclastic fault zone separates (i) minimal deformation-related microstructures as well as ankeritised dolomite in the hanging wall from (ii) folded (ultra-) mylonitic marbles in the footwall. The faults dip at low angle towards the NNW. The mylonites have a pronounced stretching lineation that has a maximum plunge of ca. 20°–40° towards NNE, parallel to the overall brittle kinematics extension direction.

In this poster we use the Mohr circle of the Second Kind to quantify the kinematic flow. This illustrates the amount and nature of the finite shear strain in this particular area. Non-rotated, discordant quartz filled veins represent the indicators before finite strain constraints while suitably orientated and stretched (boudined) veins are obtained as key indicators after finite strain constraints. As a realistic scenario one figure shows a high non coaxial component and a vortivity number near to 1 as well as a delta near to 135° which indicates simple shear. The undeformed- to deformed area contrast provides an exciting view of a volume-increase associated with the input of vein-fill material (assuming plane

strain and simple shear). Furthermore using a dilatancy term, we modify the velocity gradient tensor dependent on the stretching rate factor, kinematic dilatancy and vorticity number, illustrating the change in the volume increase with a changing amount of shear strain and a higher pure shear component.
In summary, lithological and structural investigations on Kea indicate that the island is a second discovery of a crustal scale detachment in the W. Cyclades. Similar to the island of Serifos (the first discovery, where the crustal scale detachment is further associated with a metamorphic core complex) we infer that the mapped shear zone on Kea is part of an extensional S-directed detachment system.
Ongoing investigations into the mechanical behaviour of the boudined veins as well as chemical rock and vein-fill material analyses will help quantify the most realistic scenario for volume-increase for our model and further to test theories of (e.g.) channel flow versus metamorphic core complex for Kea.