



Seismogenesis and permeability conditions in polyphase cataclastic fault zones (Western Cyclades, Greece)

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In the eastern Mediterranean, extending/thinning crust of the greater Aegean region involves a complex interplay of (1) Gulf of Corinth rift-expansion, (2) west- & southward retreat of the Hellenic Trench, (3) westward impingement of the Anatolian Plate, and/or (4) propagation of the Anatolian Fault system into the Aegean. Observable effects of these are: a dramatic rotational pattern of present day surface displacement velocities, intense seismicity, and intensely developed active or ancient fault systems.

In the (presently largely aseismic) western Cyclades, we have examined exposures of ancient fault systems where frequently extremely well-preserved portions of fault architecture are exhumed from a range of mid to upper crustal depths. Intriguingly, the fault systems that we examine have fortuitously well-developed and sizeable (up to 100's m thickness) fault products corresponding to significant fault maturity and persistence of activity.

Brittle deformation in the extending crust of the greater Aegean region is notably distributed. Lithospheric failure in the region includes at least two failure phases: (1) multiple low-angle cataclastic fault zones (on the islands of Kea, Serifos) formed within, and parallel to, a regional mylonitic ductile foliation and (2) a widespread system of (sub)vertical cross-cutting steep faults.

The low-angle brittle/ductile fault zones outcrop over several km and comprise cm - m thick cataclasite layers with large fault breccia fragment size distributions (0.1 - 10's cm) interlayered with few cm-thick ultra fine-grained clay-rich gouge. The gouges typically form low angle horizons that occasionally converge/branch over 10's - 100's m thereby compartmentalising the coarse fragment cataclasites into lenses/macrodomains. Although the coarse fragment cataclasites lenses are quite permeable, the

effective permeability across the fault zone is dramatically attenuated by the clay density in the interconnected clay-rich gouge network, as evidenced by domain-restricted fluid products. A priori co-seismic deformation (i.e. pseudotachylites) is absent in the low-angle fault zones. Highly fluidised cataclasites that fill hydraulic injection apophyses at their margins are, however, interpreted by us to be co-seismic. Interestingly, S/C fabrics are developed in the cataclasites. These viscous deformation mechanism features are critical evidence of strain-rate dependent (stable sliding, aseismic) failure periods of the seismogenic crust.

The widespread system of (sub)vertical cross-cutting steep faults group into a NNW, and a WNW set. Both sets are notably mature, and typically comprise 10's to 100's m thick cataclasites & breccias that contain 10's cm thick fine clayey gouge-filled strands. Occasionally present are strands/lenses of coarser/immature cataclasites plus "strong" re-cemented carbonate breccias. These zones are important evidence of early high permeability that has been subsequently lost due to re-precipitation processes. The main cataclasites and fault breccias maintain, however, a high permeability. Pseudotachylites are abundant in the steep faults. They are frequently located at the margins and/or are re-brecciated, indicating their earlier (i.e. deep crustal) generation in the ongoing fault system evolution. S/C cataclasites in these steep fault zones are disappointingly rare, however, we interpret well-developed fluid-related phyllosilicate slip surfaces in the thick clayey gouge strands (including multiple internal displacement surfaces \pm slickenlines) as the product of rate-dependent, aseismic creep.

The low angle cataclastic fault zones are regarded as the upper crustal expression of the failure of regionally thinning crust (see Müller et al., and Voit et al., session TS5.4, this meeting). The steep fault suites may be related to more than one regional event (e.g. Gulf or Corinth opening, growth of the Anatolian Fault system). Slickenlines inferable movement sense(s) on reliable fault surfaces (i.e. not free internal block) is frequently multi-stage. This implies multiple activation periods and is consistent with the unusual thicknesses and maturity of the fault zones; the faults were active during extensional and/or strike slip regimes.