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Eocene to post-Miocene kinematic evolution of the central Cyclades (Greece)

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Due to the extraordinary geotectonic location of the Aegean above an active subduction zone and an exceptional high seismicity, this area and especially the Cyclades have been in the focus of structural investigations for several decades. The present deformation is the result of ongoing plate tectonic movements in this area since at least the Miocene. The ductile structures of the Miocene extension and related metamorphic core type deformation are quite well studied and understood. Equally well investigated are the active tectonic deformation and associated brittle structures through several decades of seismic records. However, due to the difficulties of dating brittle faults, the kinematic evolution from the early to middle Miocene ductile structures, to later Miocene brittle-ductile and brittle faults is much less understood.

For these reasons detailed structural fieldwork, combined with Ar-Ar geochronology and P-T studies, have been carried out on the uninhabited island of Despotiko, SW of Antiparos, which is situated virtually in the center of the Cycladic islands. This island has been selected because the existence of metamorphic rocks penetrated by Messinian rhyolite pipes and Pleistocene eolianites provide exceptional age constraints for Eocene to post-Miocene deformation structures.

Despotiko is part of lower structural levels of the polymetamorphic Blueschist Unit of the Attic-Cycladic Metamorphic Belt and correlated lithologically with the Parikia gneisses and Marathi unit of Paros. Foliation is shallowly dipping towards the SSW. The main lithologies of the island, from the footwall to the hanging wall, consist of dark to pale grey, strongly foliated, mylonitic granite gneiss with abundant pegmatite dikes. The gneiss is overlain by prominent white, strongly foliated, mylonitic gneiss. Above are medium-grained, white calcite marble followed by greenish-white, mylonitic gneiss and an alternation of mica schist, greenschist, thin marble layers and some small serpentinite lenses. The structurally highest levels, in the south and southwest of the island, comprise several tens of meters of dolomite marble. This metamorphic succession has been cut by six Messinian rhyolitic volcanic vents and all crystalline rocks have been covered by late Pleistocene eolianites.

The kinematic evolution of the investigation area can be divided based on the deformation style and age.

(1) The ductile deformation results in NE-SW trending stretching lineation and shear senses both top-to NE and top-to SW. Ar-Ar white mica cooling ages indicate an early Miocene age for this ductile deformation.

(2) The brittle/ductile structures, which gradually advance from the previous ductile deformation, start with small but pervasive flanking folds, followed by larger shear bands and finally faults with tourmaline slickenlines. The shear sense is consistently top-to SW with middle to late Miocene age constrained by Ar-Ar white mica cooling ages and zircon fission-track data from Paros.

(3a) Large, subvertical, sinistral strike-slip faults cross-cut the metamorphic rocks and show up to hundreds of meters displacement. Late Miocene age is constrained by apatite fission-track data from Paros and the observation that these faults are sealed by Messinian rhyolites.

(3b) The Messinian volcanic rocks are almost exclusively deformed by E-W striking conjugate brittle normal faults, which started already during the formation of the volcanic rocks. No unequivocal tectonic deformation structures have been observed in the Pleistocene eolianites.