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Multistage Plutonism and the Serifos Detachment System (Cyclades, Greece)

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Exhumation of metamorphic rocks by low angle detachment faulting is probably due to widespread regional extension and related to a southwards retreat of the Hellenic subduction zone. Some central Cycladic islands have been suggested to represent metamorphic core complexes (MCC), characterized by asymmetric ductile to brittle detachment systems. Frequently they are intruded by syn- to post-tectonic plutons.

During the Middle to Late Miocene, numerous acidic granitoids were emplaced in the Cycladic area. Granite chemistry literature data identifies three different types/ provinces varying in whole rock chemistry, mineralogy, isotopic composition and intrusion ages: The I-types of the central and eastern Cyclades, the I-type granodiorites and dykes with similar composition to the western Cyclades, and peraluminous Bt-Ms and Ms-granites with S-type characteristics and leucogranites.

Our work on Serifos has identified a detachment system and multistage plutonism. We newly observe S-type granitoid intrusion(s) marked by early formation stages of an amphibolite-facies, island-wide outcropped low-angle detachment. A NNE-SSW directed stretching lineation and spectacular shear sense indicators give SSW-directed kinematics. These early granitoids are deformed into protomylonitic orthogneisses and, within the high-temperature (HT) shear zone, to mylonites that locally still preserve magmatic relics. No migmatisation is however observed. This HT detachment represents the initial stage of a multi-stage MCC formation. Rb-Sr muscovite cooling ages from the orthogneisses yield ages of 15-12 Ma. Some displacement on the de-

tachment almost certainly occurred between 12 & 15 Ma. Moreover, the S-type granite intrusion must be older or coeval. A detachment thickness of approximately 200m and the presence of sheath folds imply deformation at high strain and displacement of tens of km´s.

During continued crustal thinning, extension, cooling and unroofing of the MCC, a second, later detachment horizon that is developed at greenschist facies conditions is recognized throughout Serifos. This lower temperature (LT) detachment comprises ductile mylonites and brittle/ductile ultra-cataclasites. Kinematics are consistent with the HT detachment, i.e. SSW-directed. The hitherto recognized Hbl-Bt-granodiorite plus subsequent granodioritic to dioritic dyke generations accompany this MCC stage. At its northern margin, the granodiorite is undeformed and crosscuts all detachments. At its southern margin the granodiorite is foliated and mylonitized by the LT detachment. This granitoid/ detachment crosscutting relationship impressively demonstrates the syn- to post-kinematic intrusion of the Serifos granodiorite. We obtain granodiorite intrusion ages of approx. 11.3 Ma (single grain zircon TIMS U-Pb) and cooling ages of approx. 8.0–8.5 Ma (Rb-Sr on Bt). These new data, together with published apatite fission-track ages of 5.3–6.7 Ma (Hejl et al. 2002) suggest very high (initial) cooling rates. Intrusion depth constraints are problematic; however the graphic intergrowth of interstitial, xenoblastic Kfs with Qtz and the spindle-shaped cores of long prismatic zircons suggest a sub-volcanic evolution and intrusion of the granite at shallow crustal-level.

Serifos Island represents a textbook example for a hitherto unrecognized high-low-temperature multistage magmatic and metamorphic core complex and the first example in the western Cycladic area. Although there are strong affinities with the ca. 40 km-wide belt of known MCCs (Paros-Naxos-Ios) in the central Cyclades, Serifos has differences in kinematics. Interesting, although the main granodiorite is younger than those in the central Cyclades, our early ($>$15Ma) S-type granite is based on geochemical, microstructural and geochronologic investigations, strikingly comparable to similar granitoids of the adjacent Cycladic islands. Our studies therefore show the regionally protracted nature of this tectonic regime. Moreover, our geochronology data constrain temporal evolution for this major crustal extension in the western Cyclades and require a marked geodynamic evolution that must involve a westward propagation of Aegean extension from the central Cyclades. This westward propagation is a critical data point for lithosphere models (e.g. Jolivet, 2001) and seismology investigations (Sorel, 2002, Chery, 2001) that invoke the present day (seismically active) extension in the Gulf of Corinth (a further 120 km northwest of our constraints for Serifos) within the overall eastern Mediterranean geodynamic evolution.

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