



Early to Middle Miocene cooling ages on Kea and Kythnos: timing constraints on crustal extension in the western Cyclades

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The Cyclades are known for their extensional tectonics and recently recognized as having significant bivergence with top-to-NNE and top-to-SSW kinematics. Crustal extension and exhumation of the Attic-Cycladic massif, and in some instances metamorphic core complex formation are the result of back arc extension in the wake of Hellenic subduction retreat. Of the western islands, Kea and Kythnos have remained relatively little investigated even given their critical juncture between mainland Attica and the other Cyclades. Mapping by Team ACCEL indicates the islands are dominated by highly-strained middle greenschist facies Chl-Ep schists, calc-silicates and marbles, folded into open structural domes. Characterizing the tectonostratigraphy is a dominant, meter to decameter thick layer of ultramylonitic marble which is preserved in klippen scattered along the edges of the domes. The most recent brittle deformation is recorded as a number of low-angle normal faults which truncate the domal structure; both these brittle and other ductile (e.g. boudinage) kinematics indicate a consistent SW-directed stretching direction. No unequivocal hanging wall rocks have been identified and neither dome contains evidence of Alpine or younger magmatism. Ar-Ar thermochronometry performed on white mica from various lithologies at different structural levels on Kea yield consistent Early to Middle Miocene (21 Ma to 13 Ma) cooling ages. (U-Th)/He apatite cooling ages are between 14 Ma and 7.5 Ma. Although poorly defined, the older cooling ages are in the middle of the dome and along the geomorphic 'spine' which defines the dome's long axis. White mica from Kythnos yield poor age spectra with integrated ages between 22 Ma and 17 Ma, likely indicating mixed mineral populations were analyzed. The (U-Th)/He apatite cooling ages from this dome are all consistently Middle Miocene, with no evident spatial pattern. We interpret the Early to Middle Miocene cooling ages of the Kea and Kythnos metamorphic domes to represent the timing of extension and exhumation under moderate to rapid conditions. The structural style and metamorphic grade suggest these islands are exhumed portions of the Hellenic brittle-ductile transition zone. Except for the few younger Late Miocene ages on Kea, the bulk of our results are in marked contrast to the cooling pattern that has emerged on Serifos, a SSW-directed extensional dome directly adjacent to the south. Exhumation of the Cycladic metamorphic domes in general was accommodated along interfering and sequentially developed extensional detachment zones; the disparity in timing between the northern domes and Serifos may be a reflection of this detachment geometry and further indicates the relatively protracted nature of Attica-Cycladic extrusion since the Early Oligocene.