Fluid circulations in detachment faults: insights from Mykonos Metamorphic Core Complex

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Back-arc basins are known to be controlled by deep subduction dynamics. In the Aegean domain, the slab retreat led to the formation of crustal-scale Low Angle Normal Faults (LANFs) that were involved in the exhumation of Metamorphic Core-Complexes (MCC) in this region. The North Cycladic Detachment System (NCDS) is an example of these LANFs. These large-scale structures are associated with heat exchange and fluid circulations representing a major interest in the understanding of metallogenic provinces and hydrothermal systems. The Menderes massif of Western Anatolia is the location of an active exploitation of high-temperature geothermal resources related to extension and the activity of the main detachments. However, there the rock-fluid interactions in the deep part of the geothermal reservoir are not accessible to observation. The Miocene MCC of Mykonos (Cyclades) represents instead a perfect example to study those systems because it combines detachment faults, a magmatic event, a sedimentary basin and baryte-iron-hydroxides veins exploited until the 80’s. The NE-SW post-orogenic extension is accommodated in the island by the Livada and Mykonos detachments that belong to the NCDS. These detachments are coeval with the emplacement of granitoids and associated to the formation of a supra-detachment sedimentary basin during the Late Miocene. These detachments are strongly related to a dense network of barite, Fe-oxo/hydroxide or Fe-sulfur veins that emplaced during the synkinematic cooling of Mykonos granitic laccolith. The observed fluids in the granite below the detachments show two distinct sources, seawater and a magmatic fluid. However, in the sedimentary basin, the emplacement and the nature of fluids and their interaction with deformation remain poorly investigated. Based on field observations and geochemical analyses, this study aims to propose a scenario of fluid circulations in the Mykonos sedimentary basin by characterizing and tracking them. Raman spectroscopy on fluid inclusions and bulk-rock geochemical analyses were performed to respectively understand fluid sources and hydrothermal circulations. Our observations led us to suggest a mineralization emplacement model during the synkinematic cooling of the laccolith intrusion. First, Mykonos detachment isolates two different domains in term of fluid circulations: strongly reduced magmatic fluids below the detachment and oxidized fluids above it. Further extension and formation of normal faults promoted the progressive connection of these domains. In barite from the detachment, the coexistence of low-salinity fluids and brines in coeval fluid inclusions suggest a boiling phase that could be related to the opening of the system by pulse. Moreover, iron-leached infiltration zones in the overlying sediments witness the percolation of magmatic reduced fluids, able to mobilize Fe$^{2+}$ and to
transport it towards oxy-hydroxide-rich veins. These reduced fluids also allowed baryum leaching from magmatic feldspar, while mixing with seawater (rich in $\text{SO}_4^{2-}$) in the detachment could be responsible for barite mineralization during and after the deposition of the sedimentary pile in Mykonos.