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Thermal evolution from Triassic to Jurassic of the upper mantle beneath the Pindos Ocean as implied by ultramafic rocks in East Othris, Greece

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The East Othris ophiolite ultramafic members consist of serpentinites, as well as serpentinized harzburgites and lherzolites, intruded by thin dykes of olivine-websterites, websterites and clinopyroxenites. This ophiolite sequence represents parts of partially altered upper mantle wedge rocks in a Mid-Late Jurassic intraoceanic subduction setting of the Pindos micro-ocean in the western Tethys. Petrogenetic modelling[1,2,3] of geochemical and mineral chemistry data[4] reveal that the serpentinized harzburgites (Mg#=88.59-90.42; Al_2O_3=0.69-1.25 wt.%; Yb=0.06-0.10 ppm, Dy=0.07-0.15 ppm; Spinel cores Cr#=38.22-67.04) correspond to highly depleted residual mantle peridotites which were formed after moderate degrees (~13-20%) of hydrous partial melting, whereas serpentinized lherzolites (Mg#=90.37; Al_2O_3=1.98 wt.%; Yb=0.14 ppm, Dy=0.14 ppm; Spinel cores Cr#=18.03±2.23, 1σ) resulted after lower partial melting degrees (~7-10%).

Pyroxenites were most likely derived after crystallization of a subduction-related IAT hydrous magma that formed after moderate partial melting of depleted peridotites. A hypothetical IAT primary magma was calculated assuming only olivine fractionation from the average composition of the olivine-websterites. The composition, as well as the liquidus and mantle potential temperature of the subduction-related primary magma, were calculated using the PRIMELT2.XLS software[5]. The primary magma is compositionally estimated[4] of having 12.0 wt.% MgO, 9.0 wt.% CaO and 9.0 wt.% FeO, which is very similar to the average composition of boninites found in the East Othris ophiolite. Furthermore, the primary IAT magma, seems to have been formed under relatively high temperatures (liquidus temperature at ~1260 °C; mantle potential temperature at ~1372 °C)[4].

On the other hand, the study of the Pindos Triassic ultramafic and mafic rocks of East Othris show that a primary E-MORB magma was initially formed by moderate partial melting degrees (~20%) of a fertile lherzolitic mantle source at high temperatures (liquidus temperature 1326 °C; mantle potential temperature 1434 °C) followed by a Mid-Late Triassic IAT primary picritic magma, which was probably formed after higher partial melting degrees (~30%) at even higher temperature conditions (liquidus temperature 1367 °C; mantle potential temperature 1483 °C)[6]. Thus, for the same Tethyan area, from the Triassic Gondwana's northeast margin rift to the short lived intraoceanic subduction phase, and later to the Jurassic Pindos oceanic opening and main subduction phase, the estimated cooling rate is calculated at ~0.7 °C/Ma for the E-MORB mantle potential temperature and at ~1.6 °C/Ma, if we take into consideration the IAT mantle potential temperature[4]. We suggest that such high cooling rates can be mostly attributed to differences in source and melt compositions between the Triassic and Jurassic magmatic events, but also to ceasing of the impact of the plume-related mantle flows from Triassic to Jurassic.

References. [1] Hellebrand et al. 2001: Nature 410, 677–681; [2] Niu 1997: J Petrol 38, 1047-1074; [3] Shaw 1970: Geochim Cosmochim Acta 34, 237-243; [4] Magganas and Koutsovitis 2015: Int J Earth Sci, in press; [5] Herzberg and Asimow 2008: Geochem Geophys Geosys 9; [6] Koutsovitis et al. 2012: Lithos 144–145, 177-193.