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Formation of a silicic upper oceanic crust in the Troodos ophiolite, Cyprus

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The oceanic crust generally consists of mafic rocks that reflect their formation by partial melting of the upper mantle by seafloor spreading processes. However, silicic magmas occur in many regions of the global spreading axis system, for example, at propagating ridges or at central volcanoes in thickened oceanic crust like on Iceland. The felsic magmas frequently form by crystal fractionation and assimilation processes in the crust. The distribution and formation of such silicic magmatic rocks in oceanic crust can be studied particularly well in ophiolites like the Troodos Ophiolite on Cyprus that probably formed at a subduction zone. Well-preserved plagiogranitic bodies (diorite-granite) with diameters up to 1km occur between the gabbroic section and the sheeted dike complex. Dikes with andesitic to granitic composition intruded the sheeted dike complex and the gabbros. We sampled eight localities within the plutonic section and analysed 70 whole rock plagiogranite samples using XRF, microprobe and LA-ICP-MS. Additionally, over 80 glasses from the pillow lava section were studied in order to correlate the plutonic rocks to the volcanic stratigraphy.

Field observations as well as geochemical analyses suggest generation of the plagiogranitic intrusions during three different stages. A few plagiogranites show enriched compositions with high (Ce/Yb)N and apparently formed very early in the Troodos crust (stage 1) because they are intruded by mafic dikes, show strong tectonic deformation and hydrothermal alteration. Stage 2 plagiogranites are most abundant and lie on the liquid line of descent of the bulk of the volcanic glasses. They also closely resemble the lavas in terms of enrichment with (Ce/Yb)N between 1.7 and 2.8. The stage 2 plagiogranites intruded into the sheeted dike section and have frequently assimilated wall rocks as indicated by dike xenoliths. The early plagiogranites show an enrichment in Li and Mo and a depletion in Sc and Ga compared with the transitional and late plagiogranites. The late stage 3 plagiogranites resemble the uppermost bonitite lavas of the Troodos ophiolite and are depleted in many incompatible elements with a (Ce/Yb)N of less than 1.7.

The geochemical similarities indicate that the magmas forming the dikes and silicic melts were generated by similar processes in the shallow crust of the ophiolite. We suggest that the formation of the transitional and late plagiogranite intrusions is the result of extensive fractional crystallisation of variably depleted mafic melts, that possibly originated from a progressively depleted mantle wedge as indicated by the depletions in Nb and Ta. Additionally, contamination as a result of assimilation and stoping of wall rock affected the final composition of the plagiogranites. It thus appears that the Troodos crust formed an effective filter for the ascending melts leading to relatively evolved magmas in the upper 2 km of the crust. It remains to be resolved whether the lower crust is very mafic and represents the complementary composition to the upper evolved rocks and where the evolved magmas form.