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Investigation of parental magma and eruption history of olivine-rich crystal mush near Margi, Troodos ophiolite

RI CAO[1], LEE SAPER[2], LEONID DANYUSHEVSKY[3] AND GEOFFREY DAVID BROMILEY[1]

[1]University of Edinburgh
[2]Jet Propulsion Laboratory, California Institute of Technology
[3]Friendly Solutions

The Troodos Ophiolite provides a setting for investigating magmatic and volcanic processes in supra-subduction seafloor spreading environments. The Troodos extrusive sequence consists of two main suites: (1) Lower Pillow Lavas (LPL) comprised of relatively enriched andesites/dacites/rhyodacites, (2) Upper Pillow Lavas (UPL) comprised of more depleted basalt/basaltic andesites. The area around Margi, Cyprus on the northern flank of the Troodos volcanic complex, contains a sequence of both LPL and UPL. The UPL here also contains crystal-rich picrites, consisting of numerous metre-thick sheet flows and pillowed units up to 30 m in extent. Picrites consist of glassy to fine-grained groundmasses with 40-70 vol.% mm to cm-sized olivines. Olivines contain abundant melt inclusions, along with minor spinel and sulfide inclusions [1].

To explore formation of these crystal-rich picritic bodies, we conducted fieldwork to sample a suite of picritic and olivine-bearing UPL rocks, and to observe field relations. Geochemical analysis reveals significant compositional diversity within olivines and olivine-hosted melt inclusions (MIs), broadly representative of the diversity in olivine and glass compositions across the entire UPL. Reverse crystallisation modelling [5] using primitive UPL and picrite glass compositions [2, 3], and corrected MIs [4]demonstrates that picrites record considerable diversity in parental liquid compositions.

We conclude that (1) picrites were cogenetic with the UPL, sharing a similar range of H_2O-rich parental melts; 2) both record variable olivine (+spinel) fractionation from a maximum depth of 12 km; (3) picrite groundmasses (i.e., erupted liquids) were similarly cogenetic and formed following more extensive fractionation of the same range of parental liquids; and finally, (4) picrites show evidence of extensive crystal accumulation within magmatic systems, and eruption of crystal-rich magma. Equilibrium temperature estimated by olivine-spinel pairs overlap with those inferred olivine crystallization temperature predicted from our modelling, implying that olivine crystals accumulated and then erupted hot and rapidly quenched. Field evidence and petrographic textures demonstrate that eruption of picritic mush was enabled by extensional faulting and crustal thinning.

References:

[1] Saper et al. 2024, AGU; [2] Bailey et al. 1991 [3] Woelki et al. 2020 EPSL [4] Hu et al. 2021 [5] Danyushevsky and Plechov, 2011;