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Initial Results From the Oman Drilling Project Multi-Borehole Observatory: Petrogenesis and Ongoing Alteration of Mantle Peridotite in the Weathering Horizon

PETER KELEMEN[1], JAMES ANDREW LEONG[1], JUAN CARLOS DE OBESO[2], JUERG MATTER[3], ERIC T ELLISON[4], ALEXIS S TEMPLETON[4], DANIEL B. NOTHAFT[5], ALIREZA ESLAMI[6], KATY EVANS[7], MARGUERITE GODARD[8], BENJAMIN MALVOISIN[6], JUDE A. COGGON[3], NEHAL WARSI[9], PHILIPPE PEZARD[8], SAEBYUL CHO[10], DAMON TEAGLE[3], KATSUYOSHI MICHIBAYASHI[11], PROF. EIICHI TAKAZAWA, PHD[12] AND ZAHER AL SULAIMANI[13]

[1]LDEO, Columbia University
[2]University of Calgary
[3]University of Southampton
[4]University of Colorado
[5]University of Pennsylvania
[6]Univ. Grenoble Alpes
[7]Dept. of Applied Geology, Curtin University (AU)
[8]Géosciences Montpellier, CNRS, Univ. Montpellier
[9]Alara Resources Ltd.
[10]American Museum of Natural History
[11]Nagoya University
[12]Niigata University
[13]Oman Water Centre

Presenting Author: peterk@ldeo.columbia.edu

We report results from the Oman Drilling Project Multi-Borehole Observatory (MBO) and observations of gas fluxes from peridotite-hosted alkaline springs in the Samail ophiolite, which constrain the rate and consequences of ongoing "serpentinization" during continental peridotite weathering. We wish to acknowledge the extensive contributions of the Oman Drilling Project Science Team. Some results reported here are in Kelemen et al. JGR 2021, and Leong et al. Goldschmidt 2021, but extensive results from this multi-year effort warrant additional summary and discussion.

The MBO sampled tectonically exposed peridotite in the Wadi Tayin massif of the Samail ophiolite, via three cored holes and four rotary boreholes, studied via rock core observations onboard DV Chikyu, characterization of rotary drilling chips, analysis of borehole waters, and downhole geophysical logging. Later, Leong et al. measured gas fluxes regionally. MBO host rocks are partially to completely serpentinized, residual mantle harzburgites and replacive dunites which show evidence for reaction between cooling, crystallizing magmas and older residues of melting. Harzburgites and dunites are 65-100% hydrated. Ferric to total iron ratios are 50-90%. In Hole BA1B, alteration extent decreases with depth. Gradients in water and core composition are correlated. Serpentine veins are intergrown with, and cut, carbonate veins with measurable 14C, indicating an order of magnitude "serpentinization" rate of ~ 1% per 10,000 years, consistent with gas fluxes. Ongoing hydration is accompanied by SiO2 addition. Sulfur enrichment in Hole BA1B may result from oxidative leaching of sulfur from the upper 30 m, coupled with sulfate reduction and sulfide precipitation at 30–150 m. Oxygen fugacity deep in three holes is fixed by 2H2O = 2H2 + O2 plus oxidation of ferrous iron in serpentine, brucite, and olivine. fO2 deep in four other holes is 3–4 log units above the H2O-H2 limit, controlled by equilibria involving serpentine and brucite. Variations in alteration are correlated with texture, with reduced, low SiO2 assemblages in mesh cores recording very low water/rock ratios, juxtaposed with adjacent veins recording much higher ratios. The proportion of reduced mesh cores versus oxidized veins increases with depth, and the difference in fO2 recorded in cores and veins decreases with depth.