

Habitats in Serpentinizing Fluids of the Philippines: Complex Interactions Between the Surface and Subsurface Biospheres. D. R. Meyer-Dombard¹, D. Cardace², K. M. Woycheese³, and C. A. Arcilla⁴¹University of Illinois at Chicago (drmd@uic.edu), ²University of Rhode Island (cardace@uri.edu), ³University of Illinois at Chicago, (kwoych2@uic.edu), ⁴University of the Philippines, Diliman (caloy.arcilla@gmail.com).

Introduction: Serpentinization produces highly reduced, high pH waters that provide a potential subsurface microbial habitat, with typical characteristics including appreciable dissolved hydrogen and methane, little inorganic carbon, and limited electron acceptors. As these waters approach the oxygenated surface biosphere, microbial biomes shift to include members that can metabolize oxygen. As such, springs that serve as a surface outlet for serpentinizing fluids represent ecotones where these two distinct environments meet - an ecotone is defined as a distinct ecosystem that shares characteristics with neighboring ecosystems. It is also possible that surface-derived organic carbon has a substantial impact on both subsurface and surface components of these systems, varying with the degree of surface vegetation and precipitation. Here, we characterize several springs strongly influenced by serpentinization in the Zambales ophiolite (the Philippines), focusing on differences perhaps afforded by fluid flow dynamics and surface input of organic material. Field and laboratory measurements of fluids allow us to define the geochemical environments that embody these ecosystems.

Serpentinizing fluids in the Zambales ophiolite range from pH 9-11, and have low dissolved oxygen (0.06-2 mg/L) and ORP in the source pools. Actively flowing springs produce extensive travertine terraces, and low flow systems produce calcite rafts/flakes. Also present are mostly stagnant pools, with calcite “caps” providing a redox gradient between surface and depth in the pools. Variable flow rates produce variable subsurface-surface mixing capacity. Measurements of dissolved gases reveal concentrations of H₂ and CH₄ up to 0.49 mM, CO₂ up to 2.5 mM, and trace amounts of CO [1]. These Zambales sites also provide potential for differing degrees of mixing/reaction with local meteoric water, local hydrothermal fluids, and adjacent sedimentary rock units.

Recent work has reported the potential for microbial habitats in the Zambales systems, as suggested by the geochemistry of fluids collected from surface springs. A possible model for available metabolic niches includes hydrogen-oxidizing, methane cycling, Fe- and S-utilizing, and nitrogen metabolisms [1], which has so far been supported by assumed metabolisms of taxa identified via 16S rRNA sequencing of sediments and biofilms from these sites [2]. This model assumes an available carbon source - while dis-

solved inorganic carbon (DIC) concentrations are < 2 ppmC (essentially below the calibration limit of the analysis), DOC was found to be between 0.3-0.8 ppmC [1]. This latter could change substantially during heavy rainfall, as the Philippines ophiolites are heavily vegetated (marking a major difference with many previously studied terrestrial serpentinizing systems).

Complicating our view of carbon availability is the potential for mixing with atmospheric CO₂, once the fluids reach the surface environments (where they are subsequently sampled). Here, we use carbon isotopic signatures of biofilms and fluids recovered from several Zambales spring locales to investigate the degree of surface-subsurface interaction in the pool fluids. These data are reported in Cardace et al., 2015, however, a synthesis of pool regime, fluid flow, and microbial communities will be presented here. Rapidly flowing pools are expected to maintain a carbon isotopic ratio similar to that of the subsurface fluids, as ORP remain low in surface samples. Conversely, open exchange with the atmosphere in stagnant pools creates a gradient of oxygenated surface fluids and reduced bottom fluids. The addition of organic carbon from entrapped plant and animal material is also taken into account.

Together, these data paint a picture of the metabolic and diversity landscape of surface and subsurface ecosystems that are relevant when compared with other terrestrial serpentinizing systems as analog sites for astrobiological consideration. Current interest in serpentinization on Mars [3, 4] makes such analog investigations timely.

References: [1] Cardace, D. et al. (2015) *Frontiers in Extreme Microbiology* 6:10. [2] Woycheese, K. M., et al. (2015) *Frontiers in Extreme Microbiology* 6:44. [3] Sleep, N., Bird, D., and Pope, E. (2011). *Phil. Trans. R. Soc. B.*, 366, 2857-2869. [4] Russell, M.J., et al (2013) *Phil. Trans. R. Soc. B.*, 368:1622.