MINERALOGICAL DIVERSITY IN ULTRAMAFIC HOST ROCK AND TRAVERTINES ASSOCIATED WITH HIGH PH, ACTIVELY SERPENTINIZING SPRINGS IN THE PHILIPPINES. D. Cardace[1], D.R. Meyer-Dombard[2], C. Arcilla[3]
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Introduction: The geological process of serpentinization has been proposed as supporting the earliest geosphere-biosphere interations on Earth [1,2] and is a plausible driver of astrobiological activity in diverse planetary settings [3,4]. We surveyed the mineralogy of terrestrial serpentinites and relict peridotites, altered basalts, altered gabbros, and sedimentary deposits of the Zambales ophiolite in the Philippines, with special attention to mineral evolution as pertinent to astrobiological aspects of serpentinites. Groundwater-fed springs and wells expressing higher than expected pH were considered as possible sites of active, subsurface serpentinization; specific sites near Manleluag Springs, Poon Bato, and Bigbiga were chosen for study.

In general, serpentinization in surface outcrop samples was intense, presenting limited information about the protolith. Travertine spring deposits formed at sites where groundwaters associated with serpentinization (largely Mg^{2+}-HCO_3^- or Ca^{2+}-OH^- waters) escaped and reacted with atmospheric CO_2; travertine fabric and chemistry and in some cases suggest that Mg^{2+}-dominated waters provided the cation inventory for mineralization. Embedded cyanobacterial communities were observed in carbonate deposits as well.

Ultramafic/mafic rocks from Zambales were sampled to assess the progress of serpentinization. Bulk powder x-ray diffraction was conducted on samples consisting of altered mafic/ultramafic rocks with amphibole and anorthite; diverse secondary phases include zeolites, serpentine, magnetite, carbonates, and mixed clays. More specifically, Manleluag Springs area specimens contained thompsonite, lizardite, and a smectite-type clay mineral, as well as some calcite travertines. Regional stratified clay deposits, tectonically uplifted from the ocean floor consisted largely of calcite, smectite-group clays, and heulandite. In the Poon Bato area, antigorite and minor lizardite were detected by XRD, and calcite dominated the associated travertine specimens. At Bigbiga, amphibole-rich samples of the mafic country rock were characterized.

Thin section petrography of the same samples described above provide additional textural information. Manleluag Spring area thin sections show gabbroic country rocks, with classic twinned plagioclase in close association with pyroxenes; no olivine has been detected. Nearby travertine deposits exhibit classic layered/mounded fabrics in thin sections, with radiating calcite rims and trapped lithic fragments and expected pastel interference colors under crossed polars. At the Poon Bato area sites, serpentinite country rock specimens have complex cross-cutting relationships in vein minerals (serpentine, magnetite, possible brucite), and high order interference colors of relict olivine enclosed in serpentine mesh. Bigbiga altered mafics: excellent twinned plagioclase grains with amphiboles.

Taken together, the mineralogy and petrography data indicate advanced serpentinization of the ultramafic protolith in the Zambales region, with patchy relict olivine occurrences, representing zones of continuing serpentinization. As serpentinization is accompanied by the production of H_2 and CH_4 [5,6,7], organic compounds (though perhaps limited in diversity and abundance) [8], and is throught to drive deep biosphere processes in many distinct planetary environments, this study lays the groundwork for astrobiological study at serpentinite-associated springs in the Philippines.

References: [1] Russell, M. J., Hall, A. J., & Martin, W. (2010). *Geobiology*, *8*(5), 355-371. [2] Sleep, N. H., Meibom, A., Fridriksson, T., Coleman, R. G., & Bird, D. K. (2004). *Proceedings of the National Academy of Sciences of the United States of America*, *101*(35), 12818-12823. [3] Schulte, M., Blake, D., Hoehler, T., & McCollom, T. (2006). *Astrobiology*, *6*(2), 364-376. [4] Vance, S., Harnmeijer, J., Kimura, J., Hussmann, H., Demartin, B., & Brown, J. M. (2007). *Astrobiology*, *7*(6), 987-1005. [5] McCollom, T. M., & Bach, W. (2009). *Geochimica et Cosmochimica Acta*, *73*(3), 856-875. [6] Oze, C., & Sharma, M. (2005). *Geophysical Research Letters*,*32*(10). [7] Cannat, M., Fontaine, F., & Escartin, J. (2010). *Diversity of hydrothermal systems on slow spreading ocean ridges*, 241-264. [8] McCollom, T. M., & Seewald, J. S. (2001). *Geochimica et Cosmochimica Acta*, *65*(21), 3769-3778.