Serpentinization-driven habitability in terrestrial planet mélange terrains

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The Nili Fossae constitute a mélange terrain depression in the Syrtis Major quadrangle at 22°N, 75°E, Mars. Olivine units occur with an area of ~30,000 km^2 and high FeO compositions, ranging from 30-70% fayalite [1]. Prior work on the Nili Fossae [2] documented olivine and the presence of serpentine and other phyllosilicate deposits [3]. The aqueous alteration of olivine-rich units to serpentine-rich secondary materials in the Nili Fossae is of high interest in astrobiology. Using new analytical data for subsurface, cored serpentinites of the Coast Range Ophiolite (CRO) in northern CA, USA, we model the reaction of the olivine protolith with selected model groundwaters of diverse compositions, to monitor the bioenergetics of methane-producing and methane-consuming metabolic reactions. Major aqueous geochemical compositions relate to proposed planetary hydrospheres as Na-Cl type, Mg-Cl type[4], and Ca-Cl type waters[5], with reference to recent work on Martian groundwater [6; 7; 8]. Petrographic data for the serpentinizing Jurassic ultramafic unit in the CRO show dominant secondary phases (serpentine, other clays, carbonates, magnetite) and limited relict primary minerals (olivine, pyroxene). Major element concentrations of relict olivine grains were obtained by electron microprobe for use in this modeling study (Brown University, Cameca SX-100). Relict olivines in McL-239A, McL-329 have concentrations of MgO (~48.9 wt%), SiO_2 (~40.8 wt%), and FeO (~10.2 wt%). When modeled using Geochemist's Workbench REACT, water-rock reactions reflect shifting favorabilility [9] of methanotrophy in particular, for Na-Cl vs. Mg-Cl solutions. Clarification of the major ion chemistry in past oceans and groundwater flow systems is shown to be critical in refining this bioenergetic asessment.

[1] Hoefen et al. (2003) *Science* **302,** 627-630. [2] Christensen et al. (2001) *Journal of Geophys. Res.: Planets* **106**, 23823-23871. [3] Ehlmann et al. (2010) *Geophys. Res. Lett., **37**,* 6. [4] Murray et al. (2012) *Proc. Natl. Acad. Sci.* ***109***, 20626-20631. [5] Lowenstein & Risacher (2009) *Aquat. Geochem.* ***15***, 71-94. [6] Tosca et al. (2008) *Science* ***320***, 1204-1207. [7] Möhlmann & Thomsen (2011) *Icarus* ***212***, 123-130. [8] Michalski et al. (2013) *Nature Geoscience* ***6***, 133. [9] Cardace et al. (2015) *Frontiers in microbiology* ***6***, 10.