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Bacteria-water-rock interactions in a deep ocean gabbroic borehole and in peridotite core; International Ocean Discovery Program Expedition 399

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Water rock interactions in surface to subsurface terrestrial and marine environments are critical to the biosphere. These systems produce energy, and release trace elements essential to life. In deep ultramafic marine systems, serpentinization is particularly important to the subsurface and ocean floor biome, producing hydrogen as well as small organic molecules that support life. International Ocean Discovery Program (IODP) Expedition 399 at the Atlantis Massif (30°N, Mid-Atlantic Ridge) provided an unprecedented opportunity to examine a 20-year-old, gabbroic borehole and weathered peridotite core.

The gabbroic borehole (1309D), subjected to 20 years of bacteria-water-rock interactions, produced a friable weathered water-rock interface consisting of fossilized iron oxide biofilm intermixed with fine-grained iron-sulfide ‘mud’ on gabbro. Biofilm sampling was imprecise and occurred by scraping a 10 m long temperature-triggered water sampler down the ca. 1400 m, 1° from vertical borehole. While sample depths are unknown, the material must include some exposure to seawater oxygen over the past 20 years. Molecular, 16S rRNA gene sequencing indicated the presence of iron and sulfur cycling bacterial families such as *Desulfobacteraceae*, *Desulfocapsaceae*, *Geopsychrobactereraceae*, and *Flavobacteriaceae*. The addition of sterile seawater to these oxide and sulfide borehole materials produced positive enrichments of the following bacterial genera, important to carbon and sulfur cycling: *Acetobacterium*, *Methanococcus*, *Dethiosulfatibacter*, *Desulfovibrio*, *Desulfotignum*, *Desulfobacter*, *Desulfomicrobium*, and *Sunxiuqinia,* when incubated for 2 months at 21ºC in sealed serum bottles.

Oceanic drill core IODP-EXP399-1601A, which penetrated 60 m below the seafloor possessed an extensive weathering interval at ca. 30 m. Core recovery through this section was limited, consistent with the relatively soft, friable nature of weathered peridotite. Exposure to seawater and the subseafloor biosphere produced low bacterial abundances based on DNA extraction from weathered peridotite, consistent with unclassified *Dehalococcoidia, Pseudomonadaceae, Rhodobacteraceae, Rhodanobacteraceae, Chitinophagaceae, Nitrosococcaceae, Desulfovibrionaceae, Microbacteraceae, Geodermatophilaceae*, and *Eubacteraceae* bacterial families; possessing some unique bacterial lineages consist with marine ecosystems. DNA extraction from unweathered materials was unsuccessful. The examination of variably weathered peridotite using synchrotron X-ray Fluorescent Microscopy (XFM) demonstrated that nickel mobility from a Ni-containing groundmass occurred as micrometer-scale colloids. Continued weathering produced a novel calcium signal consistent with exposure to seawater and carbon mineralization.