Microbial weathering of ocean crust

K.J. EDWARDS[1], C.M. SANTELLI[2] AND W. BACH[3]

Geomicrobiology Group, Department of Marine Chemistry & Geochemistry, Woods Hole Oceanographic Institution, McLean Lab, MS8 ([1]katrina@whoi.edu, [2]csantelli@whoi.edu, [3]wbach@whoi.edu)

The oxidative weathering the rock type that represents the largest fraction of Earth's crust, oceanic basalt, involves a large change in free energy. If harnessed by microbes, significant biomass production may be supported. However, basalt rock habitats, remain poorly studied with respect to the microbial communities that may be supported by oxidative weathering. We are examining the early stages of ocean crust alteration using molecular microbiological, theoretical energetic, and mineralogical approaches.

Energetic calculations suggest that most biological activity in the ocean crust should occur in close proximity to spreading centers on ridge flanks where low-temperature fluid circulation is substantial. In these environments, abundant reduced basalt is in contact with oxidized fluids. Combined, aerobic and anaerobic reactions involving Fe, S, and H_2 may result in biomass production of up to one million tons of C per yr rocks aged less than 10 M.a. (Bach and Edwards, 2003). Biological activity likely declines significantly off-axis in older, highly altered crust (>10 Ma) due to the depletion of either suitable oxidants or reductants.

16S rRNA and electron microscopy studies have been conducted on the bacterial fraction of the microbial communities colonizing very young (<1 M.a.) basalt samples that displayed varying degrees of weathering. Diverse, yet distinct populations of bacteria were detected on the different samples. A general trend moving from more metal and S-oxidizing autotrophic communities towards more metal- and S-reducing populations as the samples accumulated more weathering products is suggested. Our studies indicate that a succession of microbial populations on basalt occurs during weathering and that metal, S, and C cycling are prominent characteristics of basalt-hosted cryptoendolithic microbial communities at the seafloor.

Oxidant production via electron bombardment: Progress in experimental simulations of the Europan surface environment

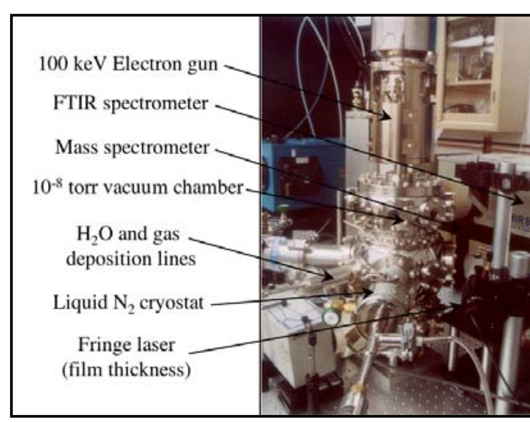
KEVIN P. HAND[1,3], R.C. CARLSON[2] AND C.F. CHYBA[3,1]

[1]Department of Geological and Environmental Sciences, Stanford University, Stanford, CA 94305, USA
[2]Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA, 91109, USA
[3]Center for the Study of Life in the Universe, SETI Institute, 515 N. Whisman Road Mountain View, CA 94043, USA

At present our understanding of the Europan system indicates that both liquid water and a suite of biogenic elements should be availble in the Europan hydrosphere. Considering the habitability of the putative ocean, the major limiting resource may very well be available free energy [1].

As a result of being situated deep within the Jovian magnetosphere, the surface of Europa is exposed to high energy, charged particle irradiation. The incident particle flux of 7.9×10^{10} keV cm^{-2} s^{-1} is dominated (>75%) by electrons in the keV to MeV range [2]. Ground based measurements and data from the Galileo Near-Infrared Mapping Spectrometer (NIMS) have revealed a suite of radiolytically produced oxidants at the surface (including O_2, CO_2, SO_2, H_2O_2,) [3-5].

In order to replicate some of the chemical processes occuring on the surface of Europa, we have constructed a vacuum chamber equiped with a high-emergy electron gun and a cryostat vapor-deposition plate (see figure). Electron irradiation of water ices has produced hydrogen peroxide and preliminary results indicate percent abundances of H_2O_2 greater than those estimated from surface observations of Europa. Implications for a subsurface ecosystem will be discussed.



References

[1] Chyba, C. F. (2000) *Nature* **403**, 381-382.
[2] Cooper, J. F., et al.(2001). *Icarus* **149**, 133-159.
[3] Spencer, J. R. et al. (2002) *Astron, J.* **124**, 3400-3403.
[4] Carlson, R. W., et al. (1999) *Science* **286**, 97-99.
[5] Carlson, R. W. et al. (1999) *Science* **283**, 2062-2064.