

Impact of patchiness in burrow distribution on sediment chemistry

T. DORNHOFFER¹, G.G. WALDBUSSER² AND C. MEILE^{1*}

¹Department of Marine Sciences, The University of Georgia, Athens GA 30602 (*correspondence: cmeile@uga.edu)

²College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis OR 97331

Macrofauna in coastal environments play an important role in benthic-pelagic coupling and sediment chemistry through their feeding and burrowing activities. Burrow formation and irrigation alter sediment characteristics and solute fluxes across the increased surface area for exchange. Although many studies have examined patchiness of benthic communities across larger scales, significant gaps in our understanding of the impact of patchiness on biogeochemical conditions and plot-scale exchange fluxes remain.

Here, we report on a coupled laboratory-modelling approach to assess the effects of patchiness in burrowing organism distributions on the distribution of chemicals in coastal sediments. Oxygen, ammonia, nitrate, and phosphate levels were measured in the overlying water of laboratory microcosms fitted with artificial burrows. The experimental data shows large sediment O₂ uptake in burrowed microcosms when compared to the O₂ flux in the absence of burrow structures. Notably, although some variability in flux values between different burrow arrangements was observed, the differences were not significant.

3-D reactive-transport model simulations, informed by measured sediment O₂ consumption rates, corroborate the experimentally observed trends. Using the reactive transport model, we assess the impact of burrow arrangements and patchy distributions on the variability and scale-dependency of field measurements. We discuss how the variability of concentration measurements is related both to the scale of measurement and the distance between burrowing organisms and quantitatively estimate the number of samples necessary to overcome the spatial variability in the field measurements.

Combined high-pressure neutron and X-ray diffraction study of H-D substitution effects on brucite

A.M. DOS SANTOS¹, J. HORITA², C.A. TULK¹, B.C. CHAKOUMAKOS¹ AND V.B. POLYAKOV³

¹Oak Ridge National Laboratory, Neutron Scattering Science Division, Oak Ridge, TN37831 (dossantosam@ornl.gov, tulkca@ornl.gov, chakoumakobc@ornl.gov)

²Oak Ridge National Laboratory, Chemical Sciences Division, Oak Ridge, TN37831 (horitaj@ornl.gov)

³Institute of Experimental Mineralogy, Russian Academy of Science, Russia (polyakov@iem.ac.ru)

The high-pressure behavior of the mineral brucite, Mg(OH)₂, is of great geochemical and geophysical interest, because brucite-type minerals serve as a simple analog for more complex, hydrogen-bearing oxide and silicate minerals in the deep-earth. A combined neutron and synchrotron x-ray powder diffraction study of hydrogenated and deuterated brucite was conducted at ambient temperature and at pressures to 9 and 20 GPa, using a Paris-Edinburgh (neutron diffraction) and a diamond anvil cell (synchrotron x-ray radiation), respectively. The two materials were synthesized by the same method and companion diffraction measurements of the two materials were conducted under the same conditions.

Our experimental results show that the lattice-parameters of the *a* axis, parallel to the sheets of Mg-O octahedra, decrease only slightly with pressure with no effect of H-D substitution. However, the *c* axis of Mg (OD)₂ is shorter and may exhibit greater compressibility with pressure than that of Mg (OH)₂. Consequently, the unit-cell volume of deuterated brucite is slightly, but systematically smaller than that of hydrogenated brucite. Fitting to a third-order Birch-Murnaghan equation shows that values of the bulk modulus for hydrogenated and deuterated brucite are indistinguishable from each other within the experimental errors. The measured effect of H-D substitution on the unit-cell volume demonstrates that brucite (and other hydrous minerals) preferentially incorporate deuterium over hydrogen under pressure, suggesting that the distribution of hydrogen isotopes in deep-earth conditions may differ significantly from that in near-surface environments.

Sponsored by the ORNL LDRD Program, and by the U.S. DOE Division of Chemical Sciences, Geosciences, and Biosciences, Office of Basic Energy Sciences.