Peering at the subsurface biosphere through a diamond window

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Investigations of the subsurface biosphere have pushed the depth limits of microbial ecosystems to greater than 800 meters below the seafloor in marine sediments and 3-4 km into the continental lithosphere. In subsurface environments, the mode-of-growth for microorganisms is attached to minerals in structures known as biofilms. In many rock-hosted, subsurface environments, organisms are confronted with multiple stressors including not only high pressures, but elevated temperatures and low energy fluxes. Subsurface microorganisms live at a precarious boundary between geologically-supported growth and cell death and remineralization. A significant limitation in the study of deep ecosystems has been an inability to distinguish and quantify microbial activities under conditions found in their native habitats. I will describe a research plan aimed at improving our ability to observe and characterize biogeochemical processes under conditions relevant to the deep subsurface environment. This plan relies upon the establishment of a one-of-a-kind research facility optimized for conducting high pressure experimental microbiology, borrowing from tools developed for materials science and hydrothermal geochemistry applications. Preliminary results show that the physiological status of microorganisms indigenous to the deep subsurface can be distinguished in vivo using molecular probes and geochemical measurements. A future goal is to make the system modular, allowing for its use in both laboratory and field-based studies. An analytical suite necessary to characterize biogeochemical transformations at microbe-mineral interfaces can be employed to follow the products of high pressure experiments, but will also be amenable to a range of studies in near-surface endolithic environments. The data obtained from these experiments will be important aid in deciphering both the extent and the biogeochemical consequences of a deep subsurface biosphere.

Using ^{222}Rn for assessing nutrient transfer into the sea via SGD

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Submarine Groundwater Discharge (SGD) has to be considered an important pathway of contaminant/nutrient transfer from aquifers into the coastal sea. One of the main reasons for temporal changes in the SGD rate is the altering hydrological gradient between groundwater and sea determined by the tidal cycle.

While SGD is known to sum up to about 6 % of the global river discharge into the oceans, the actual SGD rate in a particular coastal area is usually hard to be quantified due to the generally complex spatial SGD distribution. However, naturally occurring stable and radioactive isotopes have shown to be useful environmental tracers in SGD studies (e.g. Burnett and Dulaiova, 2003).

At Cabbé, Bay of Roquebrune (Mediteranian Sea, France), the temporal SGD pattern was investigated over a 24 h period using naturally occurring ^{222}Rn as an environmental tracer. At a location at the shore, known to represent a SGD spring, ^{222}Rn measurements of the sea water were carried out as time series using a portable radon monitor (Dulaiova *et al*., 2005). Tidal range, water temperature, and salinity were monitored using a CTD. Discreet samples for nitrate analyses were taken for assessing the nutrient transfer into the sea via SGD. In addition, off-shore surface water samples were taken along two near-shore transects.

Temporal variations in ^{222}Rn show a clear dependence on the tidal cycle. The results are backed up by the temperature and salinity data. High tide periods are characterized by lower ^{222}Rn concentrations, higher water temperatures, and higher salinities consistent with a decreased SGD rate.

Variations of nitrate concentrations basically follow those of ^{222}Rn, suggesting a strong dependence of the nutrient input into the sea on the SGD rate. In conjunction with the transect data and based on the nitrate and radon endmembers representative for groundwater (29.7 µM and 28.3 kBq/m^3, respectively) and off-shore water (both below detection limit) a nitrate flux was estimated. The results suggest that SGD may be an important nitrate source for the coastal area investigated.

References

Burnett W.C. and Dulaiova H. (2003). *J.Env.Rad.* **69**. 21-35.

Dulaiova H., Peterson R.G. and Burnett W.C. (2005). *J. Rad. Nuc. Chem.* **263**. 361-365.