THEME 4: The Earth's Surface

Session 4:4 The deep biosphere

CONVENED BY:

BO BARKER JØRGENSEN (BJOERGEN@MPI-BREMEN.DE)

HARALD FURNES (HARALD.FURNES@GEOL.UIB.NO)

NILS HOLM (NILS.HOLM@GEO.SU.SE)

INVITED SPEAKERS:

KARSTEN PEDERSEN (KARSTEN.PEDERSEN@GMM.GU.SE)

INGUNN H. THORSETH (INGUNN.THORSETH@GEO.UIB.NO)

KARLIS MUEHLENBACHS (KARLIS.MUEHLENBACHS@UALBERTA.CA)

HUBERT STAUDIGEL (HSTAUDIGEL@UCSD.EDU)

Prokaryotic organisms inhabiting the deep terrestrial subsurface (soil, rock, ground water) or marine subsurface (sediments, basalt, volcanic glass) comprise the vast majority of all bacteria and archaea on earth. In spite of the large cell numbers, carbon transformations and other biological processes in the subsurface proceed at extremely low rates compared to surface environments. Among the challenges in current deep biosphere research is the exploration of the functional diversity of the prokaryotic populations, their energy sources, their biogeochemical transforma-tions, as well as their adaptation to the subsurface environment and to a minimal energy supply. This requires integrated studies by, e.g. microbiologists, geoche-mists, and geophysicists as well as an open mind toward new and unexpected microbial environments, energy generating processes, or bacterial-mineral inter-actions. This session invites submissions on this broad spectrum of topics and aims at a truly interdisciplinary discussion.

4.4.11

The ocean crust as a bioreactor

H. STAUDIGEL[1], B.E. BAILEY[1], H. FURNES[2], B. TEBO[1] AND A. TEMPLETON[1]

[1] Scripps Institution Of Oceanography, University of California (0225) La Jolla, CA 92093 (hstaudigel@ucsd.edu)

[2] Department of Geology, University Bergen, Bergen NO (harald.furnes@geo.uib.no)

Water-rock interaction between the oceanic crust and seawater is among the most important controls for seawater composition and chemical fluxes in the solid earth. These processes are intimately linked to the biosphere as microbes utilize chemical energy from high temperature hydrothermal vents or as they mediate low T water-rock interaction through colonization and biofilm development. This offers abundant opportunities for feedbacks of biological processes with chemical processes and fluxes in a wide range of settings. This defines the oceanic crust as a bioreactor that is likely to be globally relevant as oceans cover most of the planet Earth. While high temperature fluid emissions seem to be restricted to mid-ocean ridges and some seamounts, low temperature processes may occur anywhere in the oceanic crust, suggesting that the ocean crust bioreactor (OCB) could be extremely large, covering 2/3rd of the Earth's surface area. Quantitative analysis of fossil traces of microbial interaction with basaltic glass suggest that glass alteration is dominated by biological processes, down to a crustal depth of 500m, and it has been found in ocean crust of any age in the ocean basins.

Glass alteration experiments show that bioalteration of the oceanic crust is different from abiotic alteration. Glass alteration in biotic experiments shows higher rates of chemical exchange, hydration, oxidation rates and rates of secondary mineral precipitation than under abiotic conditions. These processes are particularly relevant for the ocean crust – seawater fluxes of K, Rb, Cs, B, Ba, Sr, U, Th, Pb, even though elements like Si, Fe and Mn appear to play an important role for these processes as well.

Deep-sea exposure experiments suggest that microbes involved in bioalteration are selective in what substrate they colonize. For example, glasses exposed on Vailulu'u seamount yield cultivable Mn-oxidizing microbes only in the basaltic glass, and not in the rhyolite exposed under identical conditions.

Many open questions remain in our understanding of the OCB, including reaction rates, key microbes involved, and the elements influenced by these processes. However, it is clear that seawater ocean crust chemical cycles and their long term effects on Earth's chemistry cannot be understood without taking into account the effects of biology and the probability that these processes may have changed as life evolved throughout Earth's history.