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Microbial communities in seafloor and subseafloor basalts

I.H. THORSETH[1], K. LYSNES[2], R.B. PEDERSEN[1] AND T. TORSVIK[2]

[1] Department of Earth Science, University of Bergen, Norway
[2] Department of Microbiology, University of Bergen, Norway (Ingunn.Thorseth@geo.uib.no; Kristine.Lysnes@im.uib.no; Rolf.Pedersen@geo.uib.no; Terje.Torsvik@im.uib.no)

Seafloor (0–2.5 Ma) and subseafloor (16-28 Ma) basalts from the Arctic Ridges and the Australian Antarctic Discordance (ODP Leg 187) have been investigated by scanning electron microscopy (SEM), chemical analyses, DNA based analyses and culturing techniques, aimed at describing the microbial communities and their influence on geochemical processes in the ocean crust. All basalts have been subjected to low-temperature alteration and the abundance of Fe/Mn oxyhydroxides in altered materials along fractures and cracks indicates mostly oxidising conditions.

In the recent seafloor lavas, SEM reveals various types of filaments, coccoids, rods and stalked cells associated with the altered glassy basalt. An organic carbon content of 0.25 wt.% (delta C^{13} to -22‰) indicates 10x10 cells/g altered basalt or 10x6 cells/g seafloor basalt, assuming 10x-13g of C per cell. Cell encrustations are frequently enriched in Fe and/or Mn compared to the surrounding material. Fe-encrusted filaments similar to stalks of the iron-oxidising *Gallionella* are observed. The form and size of etch pits at the glass alteration interface suggest biotic and abiotic controlled dissolution. In the 2.5 Ma seafloor and 16-28 Ma subseafloor basalts Mn and Fe rich encrusted coccoids are observed in the outer part of alteration rims and in partially zeolite-filled fractures but not at the alteration fronts. This indicates that microbial activity continues in fractures for as long as circulation continues. The presence of microbes in seafloor lavas from different geographical regions implies that endolithic microbial growth is a general feature of mid-ocean spreading ridges.

DNA analyses show that the major part of the microbial community is unique to these low-temperature basalt habitats, differing from that of sediment and seawater from the same locations and from those of previously reported hydrothermal areas. Similar microbes in seafloor and subseafloor basalts indicate continuing microbial activity in lavas at the surface stage for at least up to 28 Ma. The microbial diversity is however lower in subseafloor basalts than in seafloor lavas. Differences between microbial populations in subsurface basalts and breccias further suggest an influence of lithology and subsurface physochemical conditions. Results show that parts of the seafloor and subsurface populations participate in iron and probably manganiese oxidation and reduction and in methane genesis by use of H_2 and CO_2. Microbial cycling may influence element mobility and chemical exchange between crust and seawater.

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Pillow lavas as a habitat for early life on Earth

N.R. BANERJEE[1,2], H. FURNES[1], K. MUEHLENBACHS[2], H. STAUDIGEL[3] AND M. DE WIT[4]

[1] Department of Earth Science, University of Bergen, Allegt.41, Bergen 5007, Norway (banerjee@ualberta.ca; harald.furnes@geo.uib.no)
[2] Department of Earth and Atmospheric Sciences, University of Alberta, Edmonton, AB T6G 2E3, Canada (karlis.muehlenbachs@ualberta.ca)
[3] Scripps Institution of Oceanography, University of California, La Jolla, CA 92093-0225, USA (hstaudigel@ucsd.edu)
[4] CIGCES, Geological Sciences, University of Cape Town, Rondebosch 7701, South Africa (maarten@cigces.uct.ac.za)

Studies documenting evidence for early life [e.g., 1] have proven to be controversial [e.g., 2]. Much of the debate regarding the biogenicity of purported microfossils centers on the interpretation of the host rocks' protoliths [2]. Most protoliths are interpreted to be of sedimentary origin, however, alternate explanations including hydrothermal and even volcanic derivation have been proposed [e.g., 2]. Here we document evidence for microbial activity in ~3.5 Ga pillow lavas from the Barberton Greenstone Belt (BGB) in South Africa. This type of geological setting has not been previously explored in the search for early life on Earth.

The BGB pillow lavas are exceptionally well-preserved and represent unequivocal evidence that these rocks were erupted in a subaqueous environment. The formerly glassy rims of the BGB pillow lavas contain micron-sized, microbially generated, tubular structures mineralized by titanite. These structures are interpreted to have formed during initial microbial etching of the originally glassy pillow rims. These structures were subsequently mineralized by titanite during greenschist facies seafloor hydrothermal alteration. X-ray mapping has revealed the presence of carbon along the margins of the tubular structures. The $\delta^{13}C$ value of disseminated carbonate within the microbially altered BGB pillow rims is depleted by as much as –16‰, supporting a biogenic origin for the tubular structures. In contrast, the crystalline pillow interiors, which are devoid of the tubular structures, exhibit $\delta^{13}C$ values bracketed between those of Archean marine carbonate (~0‰) and mantle CO_2 (from –5‰ to –7‰). Similar textural and geochemical signatures of microbial alteration are commonly documented in the glassy rims of pillow lavas from *in-situ* oceanic crust and Phanerozoic ophiolites. Overlapping metamorphic and magmatic dates from the pillow lavas suggest microbial life colonized these rocks almost 3.5 billion years ago.

References

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