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Exploring breccias as uncharted microbial habitats in the oceanic crust: Insights from the South Atlantic Transect (IODP Expedition 390/393)

JULE MELINA SOPHIE KROHN[1], FLORENCE SCHUBOTZ[1], WOLFGANG BACH[2] AND ELMAR ALBERS[3]

[1]MARUM, University of Bremen
[2]Faculty of Geosciences, University of Bremen, Germany
[3]Helmholtz Centre for Polar and Marine Research

The oceanic crust is a heterogeneous habitat harboring diverse chemosynthetic microbial communities. These communities are supported by circulating seawater and seawater-rock reactions that provide nutrients and metabolic energy. The fluid pathways and the transport and distribution of chemical and microbial species are strongly influenced by the porosity and permeability of the host material. Basaltic talus breccias, as typically heterogeneous and porous sections, present ideal habitats for intracrustal life. They frequently form at slow-spreading mid-ocean ridges and seamounts but have so far not been target of microbiological investigations.

This project explores basalt breccias in their role as habitat for a deep biosphere. Investigated breccias were recovered along the South Atlantic Transect (International Ocean Discovery Program Expeditions 390/393), covering crust of 7, 15, 31, 49, and 61 Ma that formed at slow to intermediate spreading rates [1]. At all except the youngest site the basement cores comprised brecciated sections that were interpreted as sedimentary breccias formed as talus deposits.

The examination of breccias from different crustal ages and core depths reveal lithological and geochemical heterogeneity on cm- to sub-cm-scales. Breccias contain clasts of basaltic glass, aphyric to sparsely phyric basalt, in parts with glassy rims, or a mixture thereof. The basalt clasts show variable alteration intensities from incipient replacement of primary phases in gray rocks with overall low degrees of oxidation, to strong alteration of the basaltic groundmass to clays and Fe oxyhydroxides. Few core sections reveal breccias with a black–greenish occurrence, with weak to moderate alteration intensities and restricted Fe oxidation states. Basaltic glass is locally unaltered, in particular the insides of larger shards or thick rims, but most of it is considerably altered and oxidized. These rocks provide a variety of geochemical provinces with considerable redox gradients that provided metabolic energy for microbial life during alteration. We present bulk rock and mineral geochemical data including Fe oxidation states, complemented by total organic carbon contents of defined breccia intervals. These data provide first insights into bioenergetic landscapes and the capacity of breccias to facilitate deep life.

[1] Coggon et al. (2024), TX (International Ocean Discovery Program). https://doi.org/10.14379/iodp.proc.390393.2024