Geophysical Research Abstracts
Vol. 20, EGU2018-8123, 2018
EGU General Assembly 2018

Exploring microbial sulphate reduction under high temperature and pressure – Results of a pilot study on samples from IODP Exp. 370

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Sulphate reduction is the quantitatively most important process in the anaerobic degradation of organic matter in the sea floor. Due to cryptic sulphur cycling it can proceed even if sulphate concentrations are near or below our detection limits. While the effects of elevated pressure and temperature on microbial sulphate reduction have been studied for decades, almost all studies were carried out in hydrothermal systems like Guaymas Basin, whereas sedimentary non-hydrothermal systems did not receive much attention.
Expedition 370 (Temperature Limit of the Deep Biosphere off Muroto) of the Integrated Ocean Drilling Program (IODP) was specifically planned to explore the upper temperature limit of life in a sedimentary system off the coast of Japan (Heuer et al., 2017).
Due to the high heat flow in the area the geothermal gradient is high enough (ca. 100°C km-1) to sample the putative temperature-dependent biotic–abiotic transition zone at relatively shallow sediment depth but still sufficiently gradual for the establishment of distinct, thick depth horizons (>10 m) with suitable conditions for psychrophilic (optimal growth temperature range: < 20°C) mesophilic (20-45°C), thermophilic (45-80°C) and hyperthermophilic (>80°C) microorganisms. Site C0023 allows exploring the putative biotic fringe at a relatively shallow depth, but with high resolution of the temperature gradient. Radiotracer measurements of microbial turnover was one of the key aspects of this expedtion, and each parameter that can be measured by radiotracer (methanogenesis, anaerobic oxidatio of methane, hydrogenase enzyme activity, sulphate reduction) will be measured by a different group that has specialized in this kind of analysis.
Due to several logistical limitations it was decided to carry out those experiments mostly on shore, only for methanogenesis and sulphate reduction a small subset of samples was incubated at their approximate in-situ temperature and atmospheric pressure.
The sulphate reduction rate samples from the on-board incubations were processed at GFZ Potsdam to guide subsequent incubations with radioisotopes. Further experiments with additions of electron donors (e.g. volatile fatty acids, methane) explored not just the upper temperature limit of this important biogeochemical process but also the transition from mesophilic to thermophilic communities. Together with previous data from ODP Leg 190, Site 1174, which was drilled in close proximity to Exp. 370 site C0023, sulphate reduction could be detected down to over 1000 mbsf.

Acknowledgements:
This research used samples and data provided by the International Ocean Discovery Program (IODP). The authors would like to thank all personnel involved in the operations of DV Chikyu during Expedition 270 and the support team at the Kochi Core Center

References:
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