

Temperature effects on life in the deep seafloor biosphere

VERENA B. HEUER*¹, SHUCHAI GAN¹, JULIUS S. LIPP¹, YUKI MORONO², FUMIO INAGAKI², KAI-UWE HINRICHS¹

¹MARUM – Center for Marine Environmental Sciences & Department of Geosciences, University of Bremen, Germany.

*correspondence: vheuer@uni-bremen.de

²Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology, Japan.

As sediments are successively buried, geothermal heating potentially influences the turnover of organic matter, the mineralogical and geophysical properties of sediments, and the composition and activity of microbial communities in the seafloor. While temperature activation of organic matter and minerals potentially helps to sustain the deep biosphere [1], temperatures above ~80°C are thought to limit life in the deep nutrient-depleted realm [2]. Here, we investigate the impact of temperature on the deep biosphere in the Nankai Trough subduction zone off Japan, where IODP Sites C0011 and C0012 target the incoming sediments, geothermal gradients are over ~90°C km⁻¹ [3], and *in situ* temperatures are ~80°C at the maximum penetration depth of 881 and 576 meters below seafloor, respectively. At both sites, the concentrations of microbial cells drop sharply and the lipid composition of their cell membranes changes markedly once temperatures exceed 40°C. Concurrently, metabolites such as acetate accumulate in the pore-waters, and in the bulk dissolved organic matter pool (characterized by Excitation Emission Matrix Spectroscopy) the protein-like fraction increases. During incubation of sediments at *in situ* temperatures, we observed complete turnover of ¹³C-labeled glucose under sulfate reducing conditions at ~37°C, but not under methanogenic conditions at higher temperatures, at which ¹³C-labeled metabolites accumulated. Together, our findings suggest that microbial activity, community size and composition change markedly at temperatures above ~40°C. Higher temperatures go along with incomplete carbon turnover, but cultivation-independent data and incubation experiments point to microbial activity at all temperatures below 80°C.

[1] Head, I. M., Jones, D. M., Larter, S. R., 2003. *Nature* 426, 344-352.

[2] Henry, P., Kanamatsu, T., Moe, K., and the Expedition 333 Scientists, 2012. *Proc. IODP*, 333: Tokyo (Integrated Ocean Drilling Program Management International, Inc.).

[3] Parkes, R. J., Wellsbury, P., Mather, I. D., Cobb, S. J., Cragg, B. A., Hornibrook, E. R. C., Horsfield, B., 2007. *Org. Geochem.* 38, 845-852.