THE DEBITS PROJECT: INVESTIGATION OF DEEP MICROBIAL ECOSYSTEMS IN A TERRESTRIAL ENVIRONMENT

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The investigation of the extent and dynamics of deep microbial ecosystems in sedimentary basins is a relatively young and intriguing topic in today's geoscience research. With the finding of ubiquitous deep microbial life on Earth, inevitably the question arises as to how microorganisms can survive in such ancient and, from a surface perspective, hostile habitats. In addition to elevated temperature and pressure conditions, nutrient limitation and limited porosity and permeability, deep microbial communities have to cope with a decrease in the available carbon and energy sources, because of the sedimentary organic matter becoming more recalcitrant with depth (Parkes *et al.*, 2000). The activation and usability of such food or substrate sources with increasing depth is, therefore, of specific interest when investigating deep microbial populations. There are relatively few investigations of the microbiology of sub-surface coal-bearing formations.

The international DEBITS (Deep Biosphere In Terrestrial Systems) project was started in February 2004 in the Waikato coal area on the North Island of New Zealand and is especially dedicated to terrestrial deep microbial ecosystems. The aim of the project is the investigation of the indigenous microbial populations and the characterisation of their habitats using biogeochemical, organic-geochemical and microbiological approaches.

The Waikato coal area represents a perfect natural laboratory for terrestrial deep biosphere research, because in this area organic carbon-rich lithologies are intercalated with coarser grained sediments. While the coaly seams are potential substrate providers (feeder lithologies), the coarser grained lithologies might act as habitats for microorganisms (carrier lithologies), having enough permeability to enable sufficient supply of respiratory compounds and hence for effective metabolism. Within the DEBITS project a 148 m deep well was drilled at Ohinewai in the Waikare Coalfield, taking strict precautions to prevent or at least to control any contamination of the core material by surface microorganisms. The DEBITS-1 well penetrates a complex succession of interbedded organic carbon-rich layers and coarser grained mudstones, siltstones and sandstones. At a depth of about 76 m the core intersected an unconformity. Sediments below the unconformity were previously buried to more than 2000 m and therefore have experienced significantly higher temperatures, resulting in sub-bituminous coal rank, compared to the organic carbon-rich lithologies above the unconformity, of lignite rank.

Microbial *life markers (cell membrane phospholipids)* and intact and viable prokaryotic cells were detected above and below the unconformity, indicating either that sediments below this boundary have not been sterilized by increased burial and heating or that these sediments have been re-colonized after uplift. The phospholipid *life marker* profile decreases from the top to the base of the DEBITS-1 core. In contrast, the prokaryotic cell counts show no overall decrease with depth. An explanation for this discrepancy might be that microorganisms in deeper parts of the DEBITS-1 core are not necessarily smaller in number but in size due to the more extreme environmental conditions. There is a high molecular prokaryotic diversity, with some groups of *Bacteria* and *Archaea* similar to the marine deep biosphere. Methanogens (methane-producing microorganisms) were also detected and methane production occurred in long term slurry incubations.

Comparing the phospholipid (PL) abundances with the organo- and lithofacies in selected transects from organic carbon-rich to coarser grained organic carbon-poor lithologies, distinct trends can be recognized. While the organic carbon rich lithologies contain almost no PLs, the highest PL signals are generally detected at or near the transition zones, decreasing into the adjacent clay/silt/sand layers. The PL *life marker* distribution points to better conditions for the deep microbial populations in the coarser grained sediments close to the organic carbon-rich lithologies. Water extraction experiments show highest amounts of small fatty acid anions (e.g. acetate) near the transition zones (Vieth et al., this volume). A release of substrate from the organic carbon-rich seams into the adjacent sediments is suggested. Thus, the distribution of the microbial populations appears to be the result of sufficient substrate supply (most likely from the coaly layers) and sufficient pore space and permeability for metabolic exchange processes within the pore water.

Most reference samples far away from organic carbon-rich sediments contain no PLs. However, there are several exceptions with reference samples having PLs and transect samples with no PLs, which shows that there is still much to learn about deep microbial feeding processes and optimal life habitats for deeply buried microorganisms.

REFERENCE

Parkes R.J., Cragg B.A., Wellsbury P. (2000) Recent studies on bacterial populations and processes in subseafloor sediments: A review. *Hydrogeology Journal* **8**, 11-28.