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New Zealand coals: A Feedstock for Deep Microbial Ecosystems

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The discovery of widely disseminated microbial life within the deep subsurface of the Earth opened the view to a largely unknown and unexplored biosphere in the deep sedimentary successions of our planet. Whereas it was long thought that microbial life could only exist in the upper few sediment centimetres to meters, it is now known that microorganisms occur to several hundreds or even thousands of meters depth. Thus, the deep biosphere must play a fundamental role in global biogeochemical cycles over both short and longer time scales. Especially little is known about the deep biosphere in terrestrial environments and, therefore, it forms an intriguing and relatively new topic in today's geoscience research. With the finding of an ubiquitous deep biosphere on Earth inevitably the questions arise as to how these 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. The activation and usability of such food or substrate sources with increasing depth is, therefore, of specific interest when investigating deep microbial populations.
Within the scope of the international DEBITS (Deep Biosphere In Terrestrial Systems) project a series of coal samples of different thermal maturity (lignites to high-volatile bituminous coals; 0.27 to 0.8% vitrinite reflectance) were gathered from different coal mines and natural outcrops on the North and South Island of New Zealand. Additionally, samples were taken from the DEBITS-1 core drilled in 2004 in the Waikato coal area on the North Island (well depth 148 m). The DEBITS-1 well penetrates a complex succession of interbedded organic carbon-rich layers (lignites and sub-bituminous coals) and coarser grained mudstones, siltstones and sandstones and contains an unconformity at about 76 m depth. Sediments below the unconformity were previously buried to more than 2000 m and, therefore, have experienced significantly higher temperatures.
Microbial life markers (cell membrane phospholipids) indicate the occurrence of viable microbial communities above and below the unconformity, whereas the overall phospholipid life marker profile decreases from the top to the base of the DEBITS-1 core. It was recognised that the microbial communities are often associated to the coal layers suggesting the release of potential substrates feeding surrounding microbial life. Investigating the DEBITS coal series Glombitza et al. (2009) were able to show that kerogen-linked small substrates for deep microbial communities like formate, acetate and oxalate decrease with ongoing maturation of the coals, suggesting a release of these compounds from the coals with time. The main decrease was indicated during the diagenesis and early catagenesis a maturity range where temperature conditions are still compatible with microbial life. First assessments of the feedstock potential and generation rates of the low molecular weight organic acids indicates the potential of these coals to feed deep terrestrial life with appropriate substrates over geological times.

Reference:
Glombitza, C., Mangelsdorf, K., Horsfield, B., 2009. A novel procedure to detect low molecular weight compounds released by alkaline ester cleavage from low maturity coals to assess its feedstock potential for deep microbial life. Organic Geochemistry 40, 175-183.