BIOGEOCHEMISTRY

Sediments alive!

A paper that has just been published in *Nature* has directly quantified live, deep-sediment bacteria for the first time, in both old and deep sediments. Rather than a mix of prokaryotic species, it seems that the live prokaryotes in these sediments are virtually all Bacteria.

The deep biosphere is an exciting new environment that microbial ecologists are keen to explore. This environment is hundreds of metres below the sea bed, and might extend to depths at which thermogenic geosphere processes occur. Marine sediments cover 70% of the Earth's surface and contain the largest global reservoir of organic carbon. Significant bacterial populations are present in these sediments, to a depth of several hundred metres — the deepest current sample is 842 m and the oldest current sample is 16 million years old. Using standard various techniques — including microscopic cell counts with unspecific fluorescent DNA/RNA stains, such as acridine orange; cultivation of bacteria; radiotracer analyses to indicate bacterial activities and direct sequencing of high-molecular-weight DNA — estimates have been made that the bacterial biomass in these sediments represents approximately 50% of the total planetary prokaryotic biomass. However, the fraction of these largely unculturable prokaryotes that are alive has remained unclear.

One problem with counting cells using dyes that stain both DNA and RNA is that DNA can persist in the environment and in dead cells. RNA is far more labile, and although dying cells might retain DNA and transfer RNA, ribosomes are usually lost, so measuring ribosomal RNA (rRNA) should provide a better indicator of live cells. Axel Schippers and colleagues used catalysed reporter deposition-fluorescence *in situ* hybridization (CARD-FISH), together with quantitative PCR (Q-PCR), to quantify 16S rRNA to identify live bacteria in the deep sub-seafloor sediments. Comparing these results with acridine orange staining and cell counts enabled the authors to evaluate the proportion of cells that were alive.

Schippers *et al.* showed that at the ocean-margin sediments there were markedly more bacterial than archaeal species, and as the depth in the sediment increased there was a marked drop in the number of prokaryotes, particularly archaeal species. These analyses probably exclude dormant cells, which might not contain many ribosomes and could be missed, so the estimates of bacterial numbers are a lower limit. Indeed, CARD-FISH could not detect archaeal species at all in deep sediments, in contrast with Q-PCR, so bacterial species dominate in this environment. It seems likely from elemental analyses in these sediments that sulphate reduction might be the main source of energy for these bacteria.

Deep sub-seafloor prokaryotes could significantly change the chemistry of the oceans by releasing methane, a gas that has been implicated in global warming. Studying this environment is fundamentally important in assessing biodiversity, understanding global biogeochemical cycles, understanding the interactions between the biosphere and the geosphere, and understanding how marine ecosystems function. This veritable treasure trove of bacteria might reveal new species and new functions, and investigating this important ecosystem in the future should reap rewards for all those interested in biogeochemical processes.

Susan Jones

References and links

ORIGINAL RESEARCH PAPER Schippers, A. *et al*. Prokaryotic cells of the deep sub-seafloor biosphere identified as living bacteria. *Nature* **433**, 861–864 (2005)

WEB SITES

Bo Barker Jørgensen's laboratory: http://www.mpi-bremen.de/en/Bo_Barker_Joergensen.html

Deep BUG: http://www.chm.bris.ac.uk/deepbug/index.htm