Undersea microbes active but living on the slow side

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Deeply buried ocean sediments may house populations of tiny organisms that have extremely low maintenance energy needs and population turnover rates of anywhere from 200 to 2,000 years, according to an international team of researchers.

"The microbial ecosystem in deeply buried marine sediments may comprise a 10th of Earth's living biomass, but little is known about the organisms, their physiologies and their influence on surface environments," said Jennifer F. Biddle, graduate student in biochemistry, microbiology and molecular biology and member of the NASA-sponsored Penn State Astrobiology Research Center.

The populations of interest are two groups of Archaea Ð, tiny bacteria-like organisms that often are found in extreme environments such as deep-sea hot vents, inside cows or termites or in deep sediments. The samples were gathered during the National Science Foundation-sponsored Ocean Drilling Program Leg 201 off the coast of Peru.

"The samples showed strikingly elevated concentrations of cells in deeply buried sulfate-methane transition zones," said Christopher H. House, assistant professor of geosciences at Penn State. "Sulfate methane transition zones are areas where both methane and sulfate diffuse and both compounds are used by local denizens."

The researchers looked for 16S rRNA in the sediment samples and found the transition zones dominated by two groups Ð Marine Benthic

Group B and Miscellaneous Crenarchaeotal Group. rRNA is found in a cell's ribosome and is part of the protein manufacturing mechanism of a cell. The presence of a specific sequence of 16S rRNA distinguishes the types of Archaea and the analysis also identifies Archaea that are active, excluding inactive cells and fossils.

"Other researchers have found DNA analysis of sediments from some sites to indicate that the majority of organisms were Bacteria and not Archaea," said House. "We used methods that identify only active cells and found Archaea."

Another method of identifying the active populations Ð both in size and type Ð looked at intact polar lipids, an indication of live rather than fossil cells.

"These tests and others indicate that there is a sizeable and active archaeal community," said House.

Besides simply knowing that populations of Archaea exist in the deep sediment layers at the sulfate-methane transition zones, the researchers looked at the energy sources for these microbes. Many organisms living in environments with methane use the methane for energy and use the methane's carbon to grow, repair and reproduce. Looking at the carbon isotopes the researchers found that few, if any, of these Archaea used methane as a carbon source. They also found that conversion of carbon dioxide to methane was not fueling these Archaea.

"Because the carbon isotopes from the Archaea match the total organic carbon found in the sediment in general, it suggests that the bulk archaeal community uses organic compounds derived from fossil organic matter," said House.

The researchers suggest in this week's issue of the Proceedings of the

National Academy of Sciences online, that degradation of organic matter in the sediment, especially the formation of small molecules like acetate and formate, are the likely sources of carbon.

"Real maintenance energies in subsurface environments must be much lower than what has been experimentally determined in laboratory cultures," said Biddle. "If conventional maintenance energies are used, only about 2 percent maximum of the population could survive. However, cellular maintenance energies are expected to be significantly lower when cells divide at extremely low rates."

In fact, the researchers estimate that these Archaea may completely turn over population as frequently as every 70 years, or as infrequently as 2,150 years. They also suggest that the sulfate-methane transition zone is a much better environment than other areas in the sediment and that turnover rates are even lower away from the transition zone.

This is because the Archaea in the transition zone, while not using the carbon from methane oxidation, are still getting some energy from breaking down the methane molecules, energy that is not available in other portions of the sediment.

"These Archaea subsist on the sedimentary organic carbon available and the energy from breaking down methane until they accumulate enough resources to divide," said House. "Surprisingly they require much less energy to maintain and take much longer than expected until they can divide."

This international research team was lead by House, Kai-Uwe Hinrichs from the University of Bremen and Woods Hole Oceanographic Institution, and Andreas Teske from the University of North Carolina. The team included graduate students Biddle, Julius S. Lipp, Mark Lever and Karen Lloyd.

Source: Penn State