Lush Life, Deep Down

THRIVING BIODIVERSITY DISCOVERED UNDER THE SEAFLOOR

by Cherie Winner

The deep biosphere—a realm of sediments buried far below the seafloor—harbors diverse, thriving communities of life, according to a new study by scientists at Woods Hole Oceanographic Institution (WHOI) and the University of Delaware (UD).

The researchers analyzed messenger RNA (mRNA) in sediments collected 16 to 522 feet below the seafloor off Peru in 2002. They found evidence of bacteria, archaea, and fungi actively metabolizing, proliferating, and moving. Their work was published June 12, 2013, in *Nature*.

This first glimpse into the workings of the heretofore hidden ecosystem was made possible by the first successful extraction of total mRNA, or the "metatranscriptome," from the deep biosphere, said WHOI postdoctoral investigator Bill Orsi, who was lead author of the study.

Messenger RNA is highly sought after by microbial ecologists because its presence indicates that the cells that made it are still alive, and because it carries the instructions for cells to manufacture proteins. That gives researchers valuable information about the biochemical processes the organisms are using to function.

Extracting enough mRNA to conduct the studies was a difficult task because metabolic rates of microorganisms in the deep biosphere are very low and mRNA is about only 4 to 10 percent of the total RNA they make, Orsi said. "There's a certain amount of banging your head against the wall before it works."

Among the proteins they found coded for in the mRNA, many are involved in cell division, indicating that the cells that made them belong to growing populations.

The scientists also identified mRNAs for specific biochemical processes that use sulfates and nitrates, revealing new insights into the workings of the deep biosphere ecosystem. Particularly surprising was the discovery that fungi were metabolically active players contributing to the subseafloor ecosystem, along with bacteria and archaea.

The researchers also found evidence that cells in the deep biosphere are eating amino acids, which are a rich source of carbon and nitrogen and can only come from other living or recently deceased organisms. The scientists think those amino acids came from cells that lived and died in the deep biosphere, rather than remnants that drifted down through the water.

Finding so much activity in the deep biosphere has implications for understanding how chemicals cycle through the Earth system, said WHOI microbiologist Virginia Edgcomb, Orsi's mentor.

The experiment turned up another surprise: Many of the cells in the deep biosphere are making proteins to make flagella, the whiplike "tails" that propel them through a fluid environment. The researchers were even able to show that cells making flagellar proteins occurred in areas of the sediment where the pore spaces are large enough to permit flagella-driven movement. Other cells produced mRNAs related to gliding and twitching, providing strong evidence that cells in deep sediments are capable of a variety of locomotion.

"The take-home story there is, if there's room to move, they move," Orsi said. ▲

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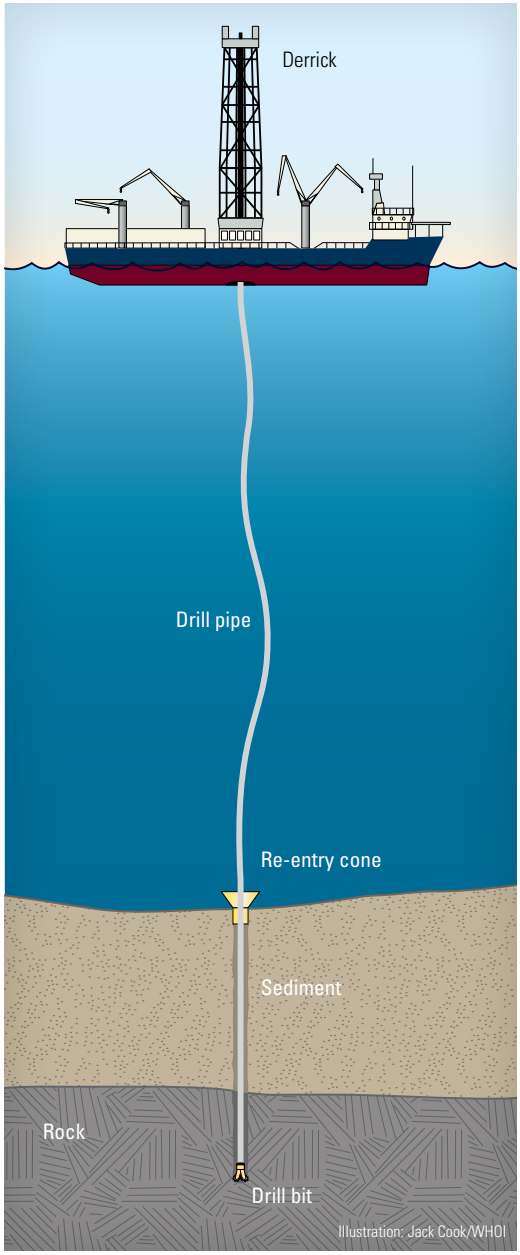

The Ocean Drilling Program's ship *JOIDES Resolution* cored seafloor sediments.