Microbes: Life Deep Beneath the Seafloor

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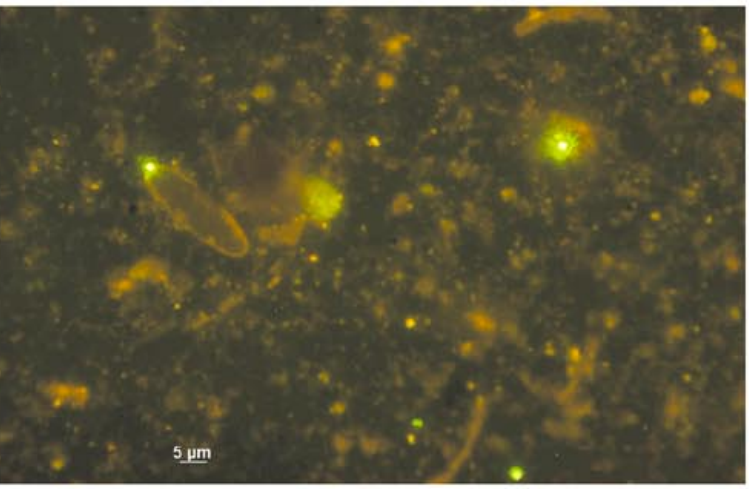

Figure 1

Eduard Suess first articulated the concept of the biosphere in 1875. A decade earlier, Jules Verne wrote of fantastic life forms inhabiting the Earth's interior in his classic "Journey to the Center of the Earth". Both men may have been surprised to find that their ideas, one rooted in science and the other in fantasy, would converge a century later deep beneath the ocean floor. Cores recovered by the Ocean Drilling Program are yielding an incredible view of life in deeply buried marine sediments (Figure 1). Finding life within the sediments is not surprising, but the great depths at which life occurs is changing the way we view the limits of life on Earth and possibly beyond.

Although Verne envisioned gigantic beasts in the subsurface, in truth, this realm is inhabited exclusively by microorganisms that exhibit great diversity in their metabolic capabilities. At its most basic level, life is a series of redox reactions, where the energy from the flow of electrons from donor to acceptor is captured to provide the energy to support basic metabolic functions. Microorganisms are exceptionally clever at exploiting even the smallest redox potential to sustain life. While most surface-dwelling organisms rely on oxygen, microbes use compounds of sulfur, manganese, iron, and carbon dioxide in the anoxic subsurface. This activity is clearly reflected in the geochemistry of the sediments (e.g. depletion of sulfate down core due to sulfate-reducing bacteria, the buildup of methane from the growth of methanogenic archaea or methane oxidation by microbial consortia at shallower depths). While ODP has recently focused on the study of life in the deep biosphere, in some sense the program has a long history in this area of research. The extensive global downhole geochemistry data allows us to predict the occurrence of specific types of microbes and calculate their metabolic rates.

To date, microorganisms have been found in sediments collected at depths as great as 800 meters below sea floor and there is no reason to believe that we have reached the bottom of the biosphere. While the great depths are impressive, even more so are the numbers at which the microbes occur. Extrapolation of microbial abundance in recovered cores to a global scale suggests that ~10% of the total biomass on Earth occurs in the marine subsurface.

Microbiology has become an integral part of the Ocean Drilling Program. The *JOIDES Resolution* now has a well-equipped microbiology laboratory that is integrated with the chemistry laboratory (Figure 2). Sea-going scientists are able to collect uncontaminated samples from recovered cores for onboard experiments (e.g. cultivations, radiotracer studies) or preserve samples for shore-based studies (e.g. nucleic acid analysis, biomarker characterization). The results of these studies will shed further light on how the Earth and its inhabitants have co-evolved.

Figure 1. Image of microorganisms in sediment cored during ODP Leg 201.

Figure 2. Scientists onboard the *JOIDES Resolution* use the microbiology lab for their research.

Figure 2