Podcast Interview: Victoria Orphan and Elizabeth Trembath-Reichert

PNAS: Welcome to Science Sessions. I'm your host Chris Samoray.

The subseafloor is a challenging environment to work in. Yet, in recent years, advances in deep-sea drilling technology have granted researchers access to a range of subseafloor habitats, where, in many cases, microbial life has been found. To study the limits of microbial life in the deep subseafloor environment, Victoria Orphan, a geobiologist at Caltech, and Elizabeth Trembath-Reichert, previously Orphan's graduate student at Caltech and now a postdoctoral fellow at Woods Hole Oceanographic Institution in Massachusetts, analyzed coal and shale bed samples from 2 km below the seafloor. The researchers discovered extremely slow-growing microbial life that resembled microbe types found in terrestrial swamps. Published in PNAS, the work was awarded the 2017 Cozzarelli Prize in Applied Biological, Agricultural, and Environmental Sciences. Orphan describes the subseafloor environment and the team's study site.

Orphan: There is no one deep subseafloor environment. It's actually comprised of a lot of different types of habitats directly connected to the overlying surface waters. These are microorganisms that are typically fed by organic material that is rained down on the seafloor, and so in the ocean gyres where there's not a lot of organics, you have microbial communities deep in the subseafloor that are living on very small amounts of organic material. Near the continental margins you have organisms that have access to more organic material as you have more runoff and more productivity along the continents. In this particular study, we were focusing on a very unique habitat, and that was an old peat bog now converted into a coal seam 2,000 m below the sea floor. We were interested in the microorganisms in this environment.

PNAS: The study site was located around 80 km off the northern coast of the main island of Japan, and accessible aboard a drilling vessel reached only by helicopter. The team used a technique called riser drilling to collect samples below the seafloor. Trembath-Reichert explains.

Trembath-Reichert: So, the way the samples are actually collected is that you drop a lead pipe from the ship down a confined tube and then it just by gravity sinks in. Then, you hook a fishing line on it and pull it back up to the ship, shove a plastic liner through to push out the core sample, and then technicians carry it onto a platform where it's cut into 1-m-long segments, and then it goes through a CT scan to help us understand where fractures might be in the sample that we might want to avoid because contamination could get in there easier. We set aside what appeared to be the most pristine samples for the microbiologists to work with. We keep them in anaerobic conditions, and then I spent about 15 hours a day crushing rocks in an anaerobic chamber and putting them into bottles in order to do the different stable isotope incubation experiments.

PNAS: Previously, archaea and various bacteria have been found in subseafloor environments. The environmental conditions of the study site, such as its temperature range and large carbon source in the form of coal, suggested that life might be present there too, says Trembath-Reichert.

Trembath-Reichert: The sedimentary history of this area is that it was this coal bed swamp, and then through geologic history it just sunk. It started to be overlaid by more marine sediments and now it's just open marine as to what's raining down on top. So, if you go through this couple km package, it's marine sediments at the top now and full on terrestrial sediments at the bottom. That has different sort of implications for the type of sediment that you would find, but also the microbes actually matched very well with a characteristic marine community versus a characteristic terrestrial community. And it is this timecapsule, essentially. The organisms that were buried when it was a swamp are still the exact same organisms that are there today, and also look very similar if you were to go to a terrestrial swamp environment today.

PNAS: To be sure, the subseafloor microbes don't encompass the full diversity of a swamp ecosystem, Orphan says. Still, the team's genetic work revealed that the microbes are more similar to microbes typically found in terrestrial systems than in marine environments. The researchers also assessed the microbes' metabolic activity and generation times using stable isotope probing incubations. The microbes exhibited extremely slow growth rates, some extending beyond 100 years. Orphan says the findings might lend insight into adaptations promoting survival and longevity.

Orphan: In this deep biosphere the variance ranged anywhere from a year doubling time up to 125 years doubling time, all living in the same piece of coal. There are a number of things that I think are really intriguing about this type of study. One is of course the potential that you have a community that has been isolated for millions of years from the surface world, and what we can learn by studying those microorganisms in even greater detail. The other is trying to understand unique strategies of survival of these organisms. An organisms that divides once every 125 years or longer, there's a certain amount of unique ability to repair yourself and to keep yourself at least chugging along on some level over all that period of time. I think there's potentially important implications on how we interpret longevity and these kinds of strategies for life. We're just beginning to scratch the surface of these really enigmatic communities.

PNAS: Orphan says it is very gratifying to see Trembath-Reichert—her former student—be recognized for the work.

Orphan: I'll say that as an adviser one of the greatest thrills is to be able to celebrate the remarkable achievements of your students together. And so, to have this opportunity to come to Washington, DC and celebrate Elizabeth's very hard fought research accomplishments is going to be something that I'll remember for a long time.

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