Deep-Sea Microbe Research

Faulhaber motors help seek climate answers in deep-sea trenches

The project team developed robots that independently descend to the sea floor and then carry out preprogrammed studies.

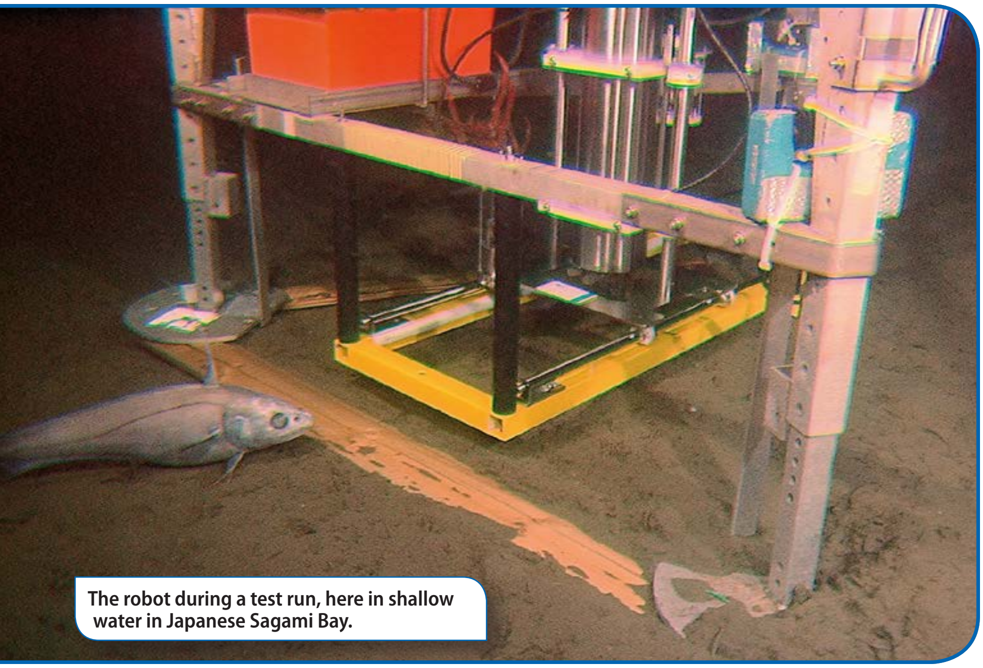
Mars is many million kilometers away from Earth. And yet its surface is better studied than the floors of the deep-sea trenches, which lie only eight to eleven kilometers below the sea surface. The biological and chemical processes that transpire there are, in fact, still largely unknown. A research project, appropriately named "Hades-ERC," is aiming to change this and supply completely new insights into the depths of the oceans. It was initiated by Professor Ronnie Glud from the University of South Denmark in Odense.

"In marine biology, there is actually a simple basic rule," Glud said. "The deeper you go, the less life one finds." Because with increasing depth, it becomes colder and darker. Less of the food produced in near surface water reach the great depths. Moreover, the water pressure increases by 1 bar every ten meters. At a depth of 10,000 meters, the pressure of approximately 1,000 bar is a thousand times higher than on the ocean shore. "But gravity exerts its effects even in this environment. A portion of the organic material that sinks to the deep ocean floor ultimately lands in the trenches, where it collects," Glud added.

Collection basin for organic material

Thus, it was no surprise to Professor Glud as he found highly active microbial communities at a depth of nearly eleven kilometers back in 2013. At that time, he had descended the instruments into the Mariana Trench in the Western Pacific.

"We found more organic matter at depths below 10,000 meters than at 6,000 meters," the marine researcher explained. "We therefore assume that the trenches have a disproportionately high influence on the nitrogen and carbon balance of the seas. Although they account for only two percent of the ocean area, they could have a disproportionately high effect on the carbon footprint and climatic occurrences."



The robot during a test run, here in shallow water in Japanese Sagami Bay.

The Hades-ERC project aims to — literally — get to the bottom of such questions and enable better understanding of the processes in the trenches. It is financed by the European Research Council, which belongs to the EU. A so-called Advanced Grant totaling 2.5 million euros allows the scientists to conduct long-term, open-ended basic research. In addition to Glud's department in Odense, marine biologists at the University of Copenhagen as well as marine research institutes from Germany, Japan and Scotland are involved. The sophisticated instrumentation is developed as a joint venture between the team in Odense and a German team headed by Dr. Frank

Wenzhoefer that is based at the Max Planck Institute in Bremen. The project is scheduled to last five years. The studies began last autumn in three Pacific trenches — the Japan Trench, the Atacama Trench and the Kermadec Trench — at depths between 8,100 and 10,900 meters. These formations were selected because the organic load in the waters above them is much different. They therefore offer their microbial inhabitants widely varying conditions.

Robots instead of submarines

While manned dives have already taken place to such depths, the use of submarines would not be practical for extensive research of bottom sediment. The project team therefore developed robots that independently descend to the sea floor and then carry out preprogrammed studies. They are equipped with sensors which, among other things, can measure the oxygen intake of the bacteria — a value from which one can make deductions on the quantity of the processed organic material. Other sensors help answer the question of whether deep-sea microbes breathe oxygen, nitrate or sulfate.

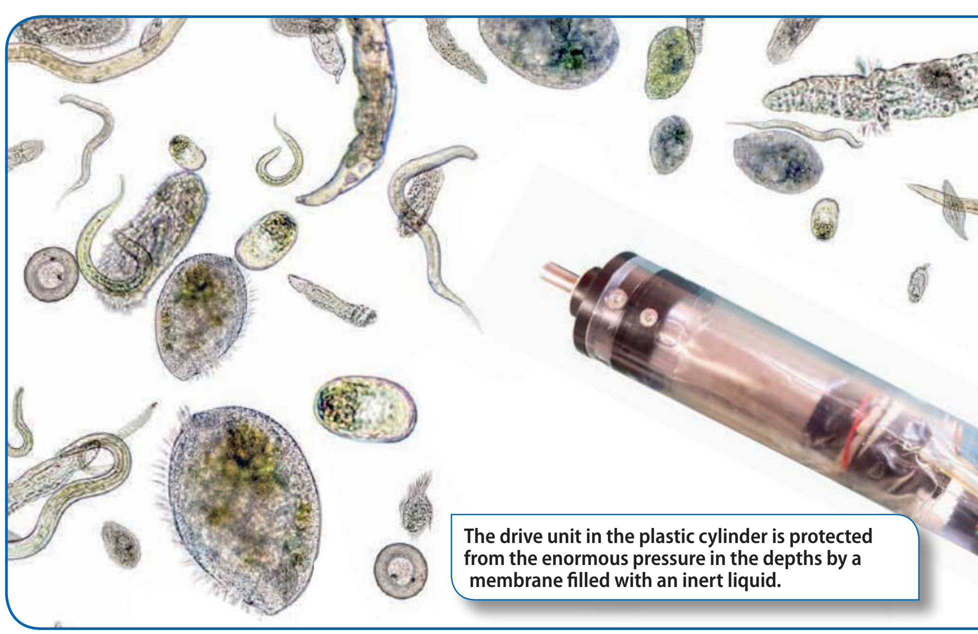
"To survive under the extreme conditions of the deep sea, the bacteria must be much different than their relatives in shallower waters," Glud said. "For example, their membranes and enzymes must function in a completely different way. How exactly, that's what we want to learn."

It is a special challenge to study the microbes themselves. Because they have adapted to an environment with enormous water pressure, they cannot simply be brought to the surface. They would turn into a "soup" on the way up, as the Danish researcher illustratively describes. The Hades-ERC robots are, therefore, provided with equipment that can inject a fixing agent into the sediment, which keeps the microorganisms intact during recovery.

Prerequisite: pressure resistance

While the microbes need to be protected from the decreasing pressure as they are brought to the surface, special precautions must be taken for the equipment in the robots to protect them from the extreme pressure in the trenches. The sensors as well as the tools for handling the sediment are specially equipped for this environment and can withstand the pressure. To perform their work, they do, however, need to come into contact with the sediment and must be moved into various positions.

Responsible for this movement are DC-micromotors from Faulhaber, provided with encoder and the



The drive unit in the plastic cylinder is protected from the enormous pressure in the depths by a membrane filled with an inert liquid.

appropriate planetary gearheads. While some components are housed in a pressure stable titanium cylinder, some devices like the motors and gearboxes can only perform their work when in contact with the surroundings that are to be studied.

"We therefore inserted these components into another cylinder in a small flexible membrane which is filled with an inert fluid," Glud explained. "The membrane ensures that the water pressure effects the enclosed components without a pressure difference occurring. Because this would crush the motors."

In an earlier version of the robot, various motors were still used for the different tasks. In practical tests, the team has come to the conclusion that it makes more sense to work with just a single, especially robust motor type.

"The robot remains at its operation site for many hours before returning to the surface with the samples. During this time, it operates completely autonomously," Glud said. "Our success is dependent on—among other things—the flawless function of the devices during this time. Thus, the motor needs to be extremely reliable, compact and strong. The model from Faulhaber has proven outstanding in the depths and is ideally suited for use under these extreme conditions." **PTE**

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