Press Releases

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JAMSTEC

Exploring the limits of life in the deep biosphere

~Microbes discovered nearly 2.5 kilometers below the ocean floor~

An international team of scientists led by Dr. Fumio Inagaki, Japan Agency for Marine-Earth Science and Technology (JAMSTEC: Asahiko Taira, President) and Prof. Kai-Uwe Hinrichs, Center for Marine Environmental Sciences (MARUM) at the University of Bremen, Germany, have explored microbial life that populates what appears to be the lower boundary of the deep sedimentary biosphere. In the current issue of *Science*, they provide proof that a microbial ecosystem exists nearly 2.5 kilometers below the seafloor, which produces methane from tens of million-year-old coalbeds.

The ocean's seabed harbors one of the Earth's largest ecosystems: the deep sub-seafloor biosphere. Microorganisms living here – bacteria and archaea – comprise at least as much biomass as all life in the overlying ocean. However, the lower boundary of this vast ecosystem has barely been documented so far. Earlier scientific ocean drilling expeditions have demonstrated the existence of microbial life down to a subseafloor depth of 1,922 meters. In order to explore the existence of life at even greater depths and to shed light on the limits of the deep biosphere, an international team of scientists undertook an expedition to the West Pacific Ocean onboard the Japanese deep-sea drilling vessel *Chikyu* in 2012.

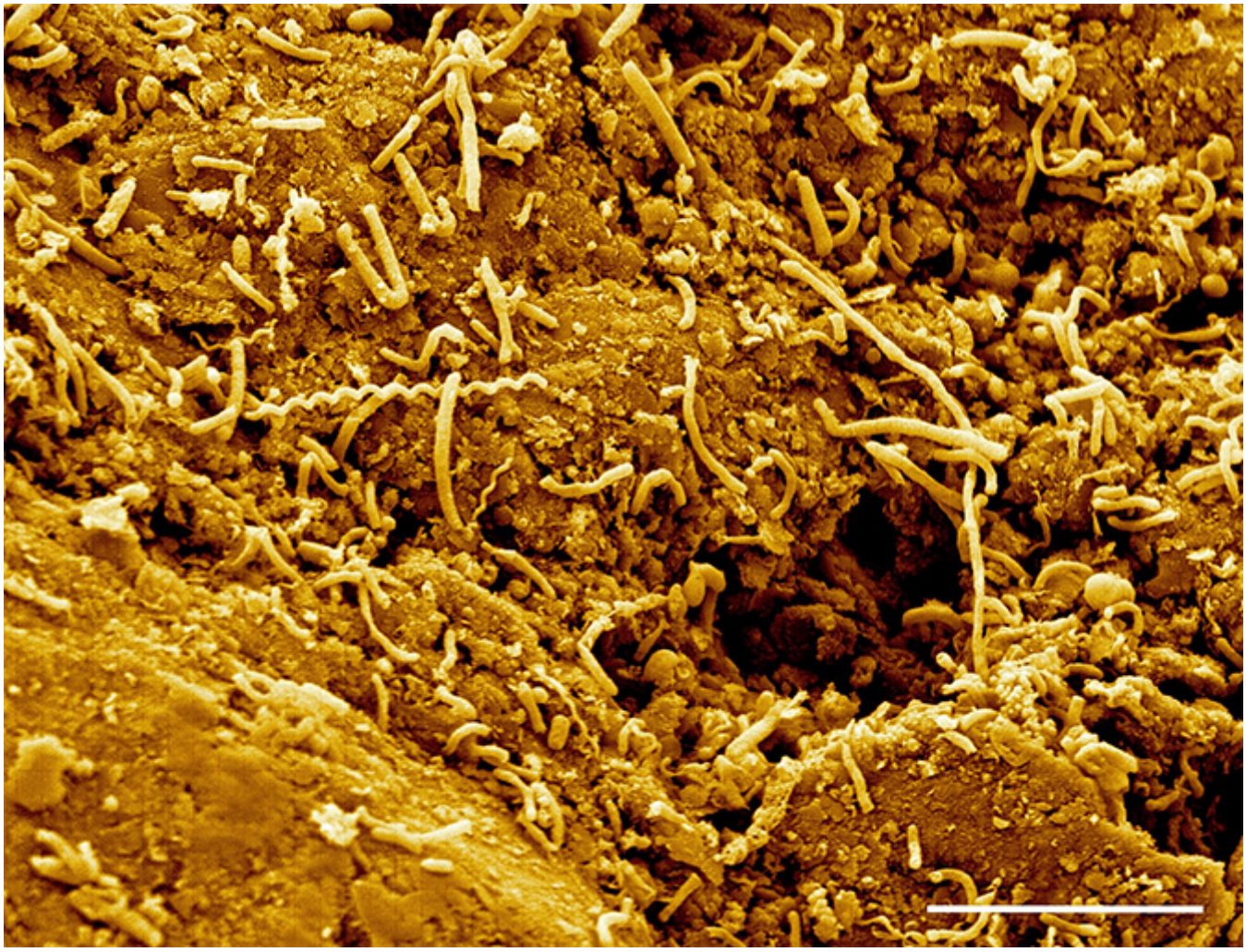
Off the Japanese coast, co-chief scientists Fumio Inagaki and Kai-Uwe Hinrichs and a team of international colleagues recovered samples from down to 2,466 meters below the seafloor – a new world-record in scientific ocean drilling. "We found cells in the bottom kilometer of the borehole. However, there were much fewer cells than we had expected based on extrapolations of observations from shallower boreholes around ocean margins." Inagaki says. "These low concentrations suggest that we may have gotten close to the lower boundary of this particular sub-seafloor ecosystem. Despite this scarcity of cells, we have compelling evidence that microbes turn coal into methane at around two kilometers below seafloor", Hinrichs adds.

This specialized microbial community lives in coal-bearing layers at temperatures around 40 to 60°C. The up to seven meter thick coalbeds formed about 20 millions years ago, when large quantities of terrestrial plant-derived organic matter were buried close to the shoreline. The resulting coastal sediments subsequently subsided due to tectonic processes, and then transformed into and buried within deep-sea sediments.

"Our analyses show that the microbial communities in the deep coal-bearing layers differ strongly from those found in the shallower sub-seafloor that typically harbors marine sediments", Inagaki states and adds: "They rather resemble communities typically found in forest soils, which makes sense given that the substrates for coal

formation originated in forest-like environments". This suggests that some community members now buried at about two kilometers below the seafloor are remnants from communities that inhabited shallow coastal soils millions of years ago. "This finding raises the possibility that the initial community deposited with shallow sediments may be a more important factor in controlling the taxonomic composition of the deep subseafloor biosphere than the geochemical conditions in the sediment", Hinrichs comments.

The fact that the deep biosphere has remained so enigmatic and full of unsolved research questions is partly due to the difficulty of obtaining pristine sub-seafloor samples for microbiological and biogeochemical research. It remains a major technological and scientific challenge to recover high-quality samples from these enormous depths. The samples examined for the *Science* study were taken in 2012 during Expedition 337 of the Integrated Ocean Drilling Program (today: International Ocean Discovery Program; IODP) with the *Chikyu*, the largest and most modern research vessel worldwide, 80 km off the coast of the Shimokita Peninsula, Japan.



Deep subseafloor life.
Using the riser-drilling vessel Chikyu, the Integrated Ocean Drilling Program (IODP) Expedition 337 explored microbial life and hydrocarbon system associated with coalbeds down to 2466 meters below the ocean floor. This photo of scanning electron microscopy shows a methanogenic community enriched from ~2km-deep coal-bed samples using a continuous flow bioreactor, which produced methane with powdered coals as the energy source. Bar: 5 µm.

Photo: Hiroyuki Imachi, JAMSTEC.

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Exploring deep microbial life in coal-bearing sediment down to ~2.5 km below the ocean floor

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