Press Releases

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JAMSTEC
The University of Tokyo
Kyushu University
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High-temperature Limit for Life beneath Deep-sea Vent
- Shed new lights on the distribution of the boundary microbial community -

Overview

A research team led by Postdoctoral Researcher, Dr. Katsunori Yanagawa at Department of Subsurface Geobiological Analysis and Research (D-SUGAR), the Japan Agency for Marine-Earth Science and Technology (JAMSTEC: Asahiko Taira, President) has carried out geochemical and microbiological analyses of core samples collected in the Iheya North hydrothermal field in the Mid-Okinawa Trough during the IODP[*1] scientific expedition 331. Based on detail characterization of genetic compositions and metabolic functions of sub-vent microbial communities, the researchers detected distribution and composition of the boundary microbial community close to the high-temperature limit for habitability in the subseafloor environment of the hydrothermal field. This study project was carried out in collaboration with The Tokyo University, Kyushu University, Kochi Uiversity, and Federal Institute for Geosciences and Natural Resources in Germany.

Previous studies have strongly suggested existence of hyperthermophiles[*2] (high-temperature-loving microbes) beneath the seafloor hydrothermal vents, though no direct evidence has been presented. To obtain evidence for active microbial ecosystems untouched beneath the seafloor, the IODP scientific expedition 331 was carried out in September 2010. It has led to significant findings about unexpected spatial distribution of hydrothermal ore deposits and their genesis (as reported on October 5, 2010 and February 25, 2016), and quantitative evaluation of drilling impact on deep-sea benthic communities (as reported on April 23, 2015) as well as potential for exploration of mineral resources (as reported on September 3, 2013).

Along with these scientific results, the researches revealed physical and chemical conditions of the limit for life beneath active hydrothermal vents. It is the most significant achievement to meet the expedition goal, shedding new lights on fundamental questions in science: *Where and What is limit for life?*

The above results were published in the online *ISME Journal* of Nature Publishing Group on October 11, 2016 (JST).

Title: Defining boundaries for the distribution of microbial communities beneath the sediment-buried, hydrothermally active seafloor.

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*1 IODP: The International Ocean Discovery Program (IODP) is a multinational cooperative project, aimed to shed light on global environmental changes, the earth's mantle and crust dynamics and tectonics, and the biosphere beneath the seafloor. The scientific drilling vessel D/V *Chikyu* operated by Japan and the *JOIDES Resolution* by the U.S, and the option to charter mission-specific platforms by Europe are utilized for expeditions. It started as the Integrated Ocean Drilling Program in October 2003 and then was taken over to the current International Ocean Discovery Program (IODP) in 2013.

*2 Hyperthermophile is an organism that grows at very high temperatures. An optimal temperature for existence is 80 °C (176 °F) or higher.

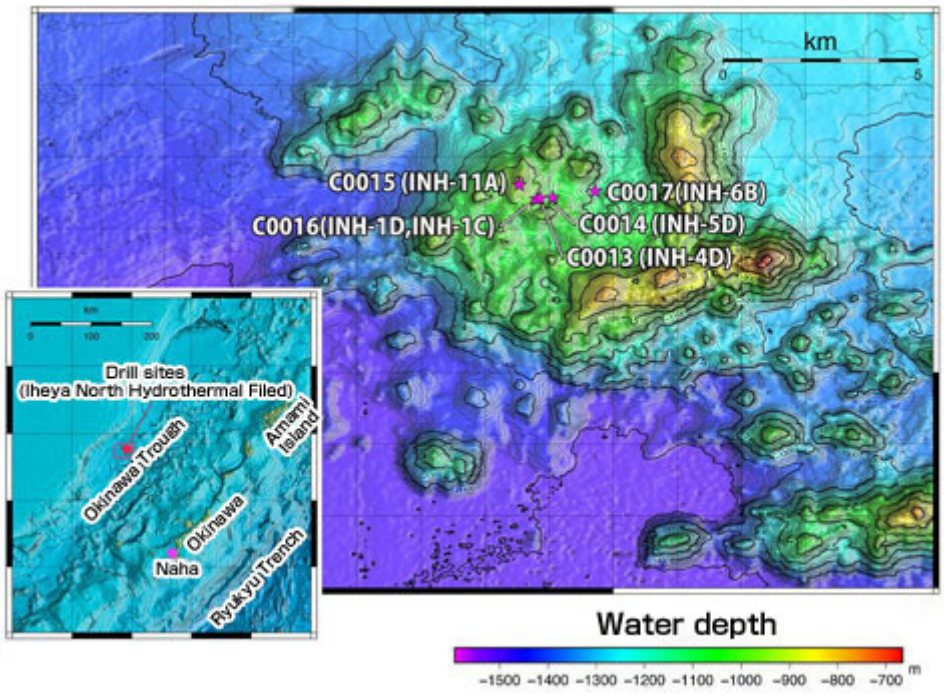

Figure 1. Research areas of this study and IODP expedition 331

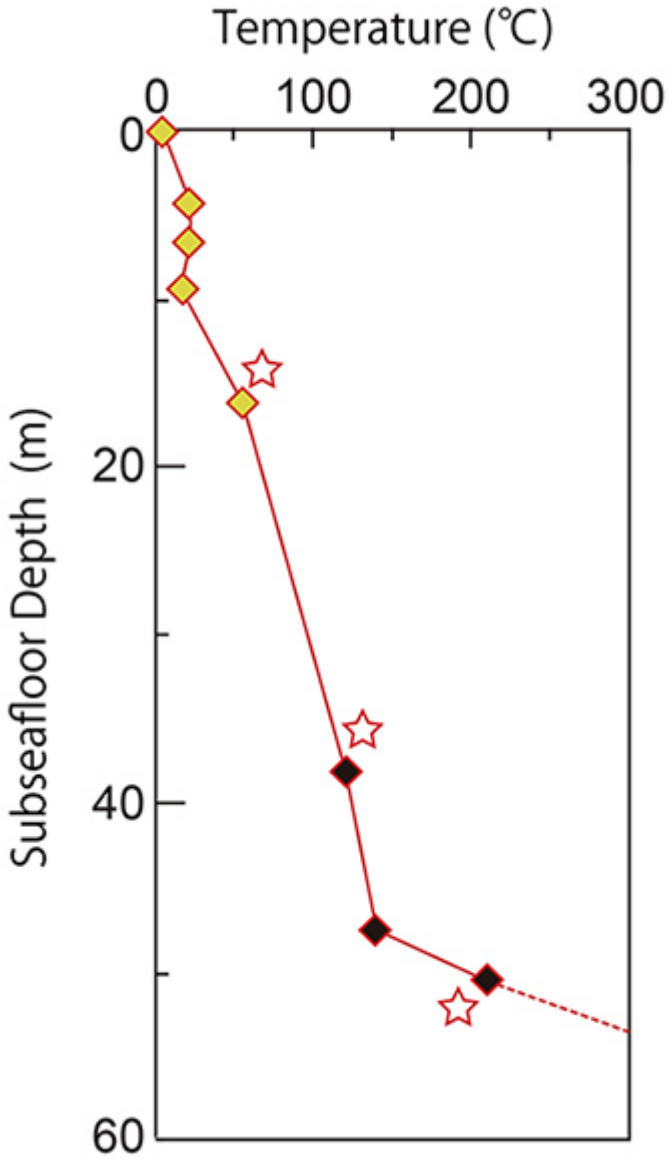

Figure 2. Temperature profile at the drilling site C0014 (revised from Takai et al., 2011). The yellow squares indciate temperature measurements (APCT-3) during drilling and coring, while the black estimation based on thermal color tapes on tubes for core liners. The stars indicate lower limits.

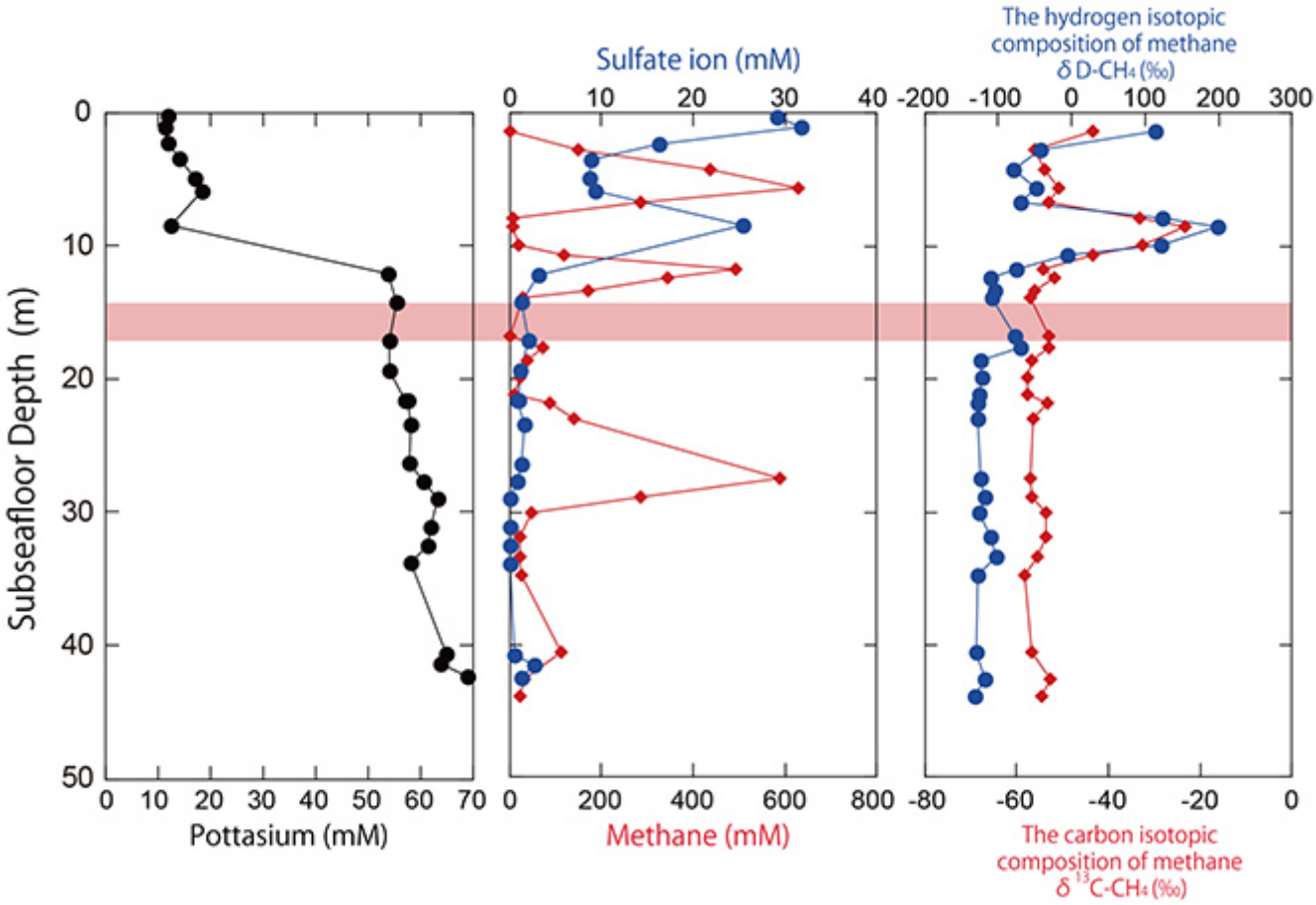

Figure 3. Chemical composition of pore-water at the drilling hole, C0014 Hole B.
A rapid increase in the pore-water potassium (K) concentration was observed below the seafloor at 10 m in the C0014 Hole B. Methane show three peaks (at 5, 11 and 27 m).
The carbon and hydrogen isotopic composition of methane becomes remarkablly higher at 8.5 m. It suggests high consumption of methane by microorganisms. The red-shaded layers represent the possible boundary between the habitable and uninhabitable regions of subseafloor microbes.

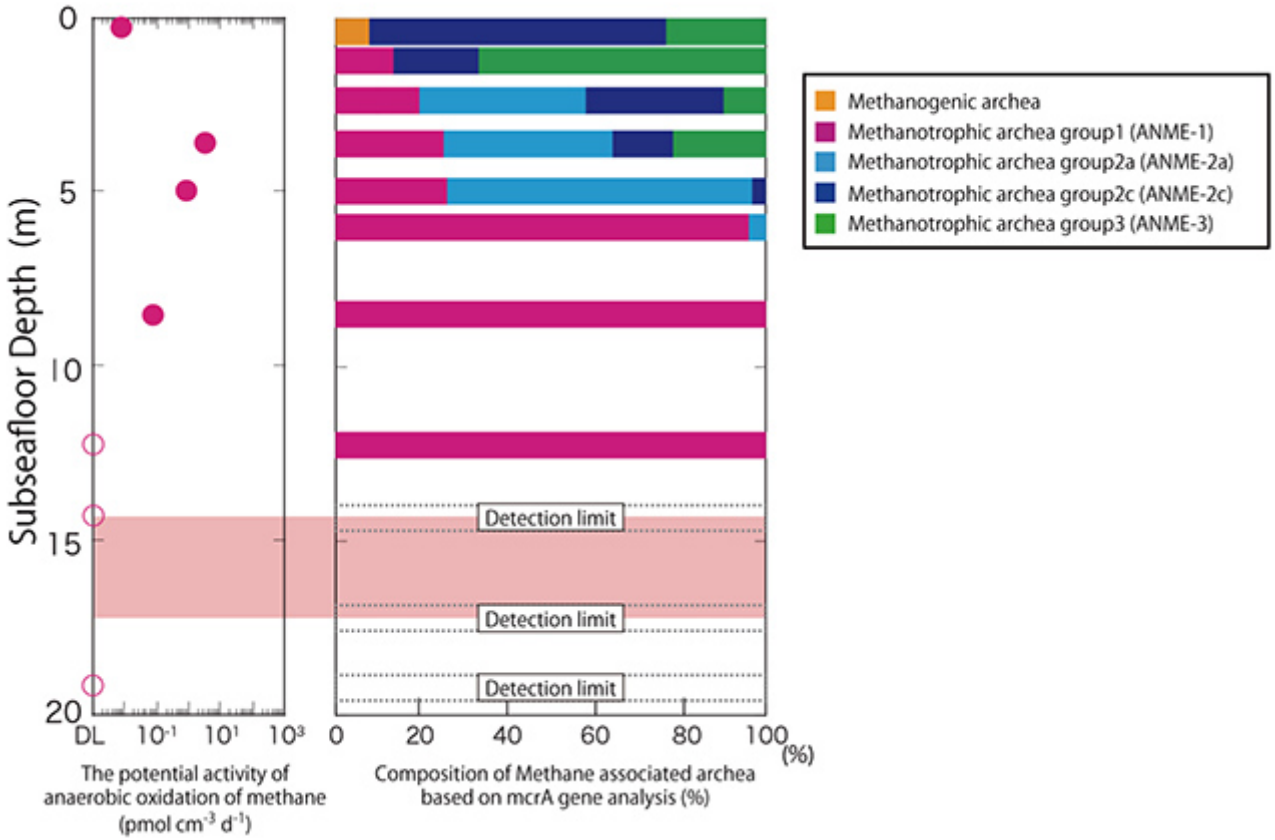

Figure 4. Depth profiles of the potential activity of anaerobic oxidation of methane, composition of potential methanogenic and methanotrophic archaea at the drilling site C0014. Open circles on the y-axes denote analyses below the detection limit. Compositions of potential methanogenic and methanotrophic archaea are determined based on the mcrA gene analysis, which encode a key enzyme for both methanogenesis and methane-oxidation reactions. The red-shaded layers represent the possible boundary between the habitable and uninhabitable regions of subseafloor microbes.

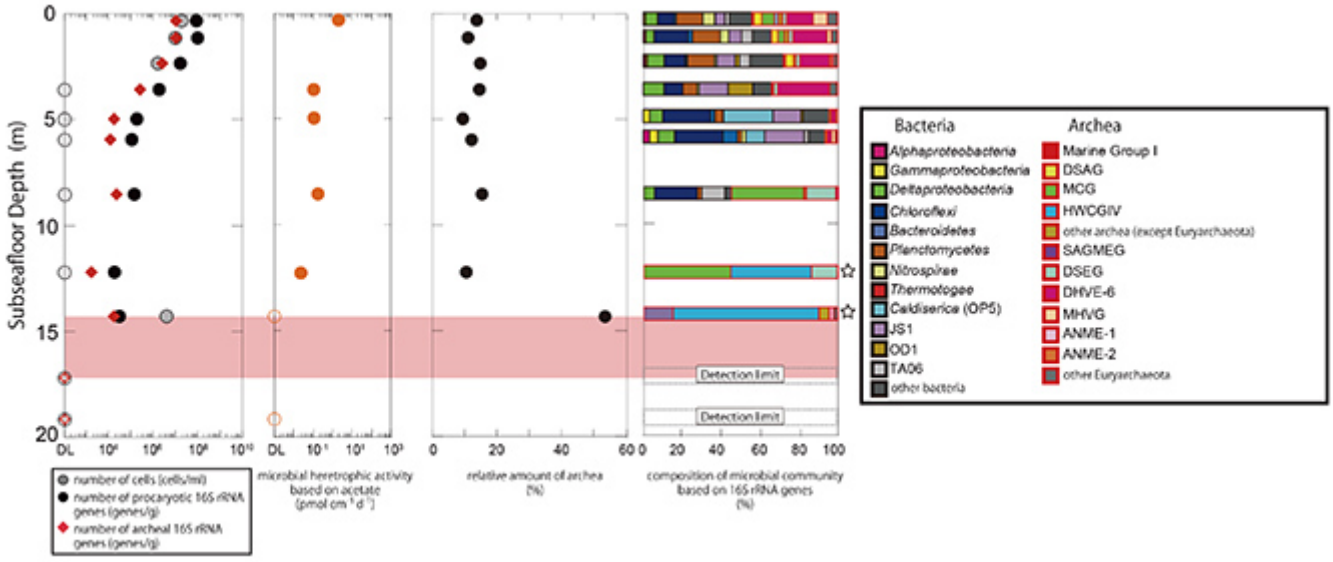

Figure5. Distributions of cell, 16S rRNA gene and heterotrophic activity, and composition of microbial communities at the drilling hole C0014 Hole B.
From left, 1) the numbers of cell and 16S rRNA gene; 2) microbial heterotrophic activity based on acetate; 3) ratio of prokaryotic and archaeal 16S rRNA genes; and 4) composition of microbial community based on 16S rRNA genes. Open circles on the y-axes denote analyses below the detection limit. At the depth marked with stars in the 4), the gene fragments were amplified only when an archaea-specific

primer set was used. The red-shaded layers represent the possible boundary between the habitable and uninhabitable regions of subseafloor microbes.

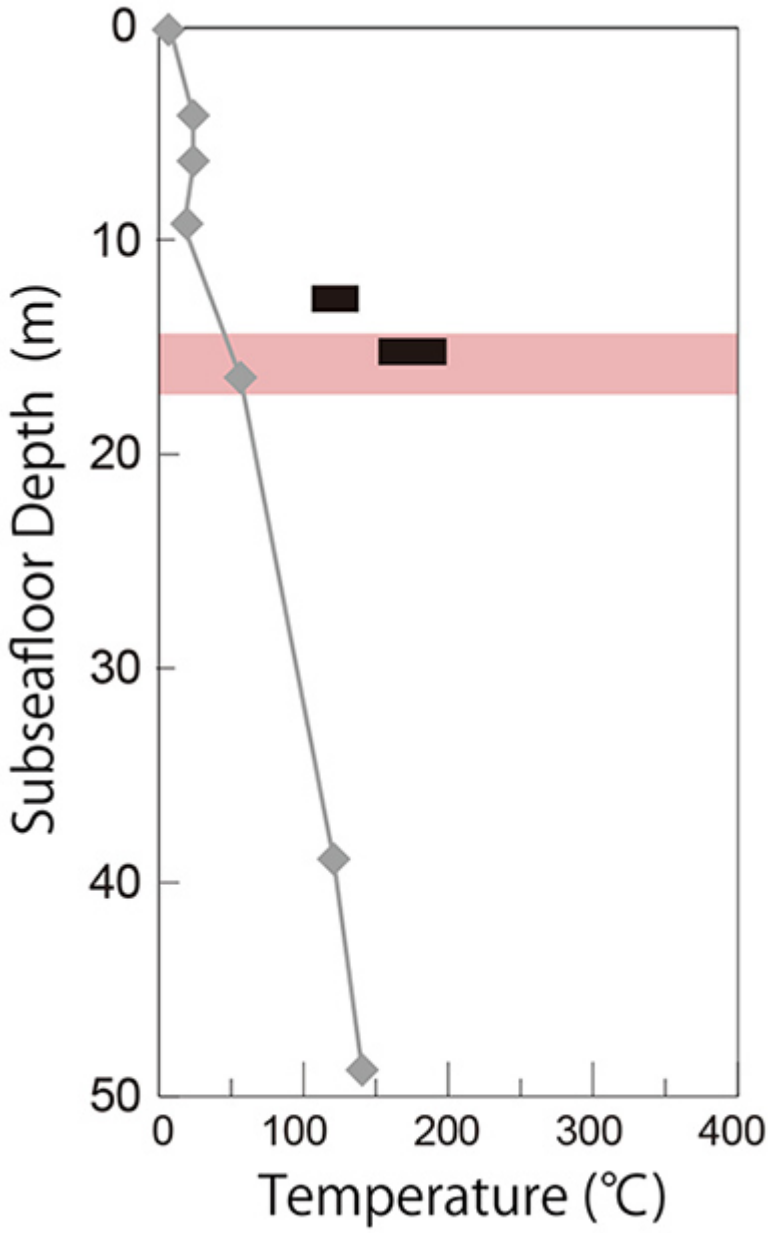

Figure 6. Comparison of measured and estimated temperatures at the drilling site C0014. Temperature profile in the figure 2 is indicated in the gray color. The black bars show temperature ranges that hydrothermally altered clays in sediments experienced, which is estimated based on the isotopic compositions. The red-shaded layers represent the possible boundary between the habitable and uninhabitable regions of subseafloor microbes.

High-temperature Limit for Life beneath Deep-sea Vent (Video)

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