October 5, 2010
Japan Agency for Marine-Earth Science and Technology

Integrated Ocean Drilling Program (IODP)
CHIKYU Completes Expedition 331:DEEP HOT BIOSPHERE

The Deep-Sea Drilling Vessel *Chikyu*, operated by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), has successfully completed the Integrated Ocean Drilling Program (IODP) (*1) Expedition 331: DEEP HOT BIOPSHERE, on 4th October, 2010. The expedition was carried out around hydrothermally active mounds in the Okinawa Trough from 1st September to 4th October.

Overview

Expedition 331 aimed to drill and sample hydrothermally active mounds to obtain evidence for microbial communities, including their biomass and ecosystem roles and functions. The drilling and coring were conducted at five sites in the Iheya North field in the Okinawa Trough: C0013, C0014, C0015, C0016 and C0017 (Fig. 1 and Fig. 2).

Two of the drilled boreholes were fitted with casing pipes (pipes for borehole wall protection), for future installation of observatories for chemical and microbial studies. The summary of the drilling operations at each site is shown in the Appendix.

The expedition was led by Co-Chief Scientists Dr. Ken Takai, JAMSTEC and Prof. Mike Mottl, University of Hawaii, and joined by 25 scientists from Japan, U.S., China, Australia and Europe.

Primary science and operational findings

1. Sub-seafloor hydrothermal fluid structure and hydrothermal alternation zone

The temperature readings from the bottom of the borehole were higher than those expected at C0013 (about 100 m east to the center of a high-temperature hydrothermal fluid plume), and C0014 (350 m further east of C0013). There, the Expedition recovered cores of volcanic sediment containing hydrothermally-altered sulfate minerals (*2). Horizontal flows of hot fluids were also found at several depths. This indicate that in the eastern Iheya North hydrothermal field, there are several layers of caprock (*3), where high-temperature vent fluids are trapped but can migrate laterally (Fig. 3). Such interaction of hydrothermal waters and seawater passing through the layers causes hydrothermal alteration of rock (hydrothermal alteration zone).

2. Sub-seafloor hydrothermal fluid reservoir

The chemical composition of pore water contained in the cores revealed the presence of lighter vapor-rich water in the upper portion of the hydrothermal fluid reservoir; heavier high-salinity water accumulated at the bottom (Fig. 3).

It is theorized that a hot fluid with high salinity sinks to the bottom of the hydrothermal fluid reservoir. The drilling into the hydrothermal mounds in Expedition 331 brought back the first direct evidence for this theory. The huge and deep expanse of the hydrothermal fluid reservoir in Iheya has also overturned the concept that the extent of fluid circulation and its flux volume are relatively small at plate convergence boundaries, such as the Okinawa Trough.

3. Distribution and mineralogy of hydrothermal sulfide minerals: clues to uncover the hydrothermal ore genesis.

The recovered cores contained a wide range of minerals composed of hydrothermally synthesized metal sulfides, providing clues to the chemical and depositional environment. It is commonly known that hydrothermal mounds (e.g. Site C0016) consist mainly of sulfide minerals. The Iheya hydrothermal system is not an exception; especially at C0013 and C0014, veins of sulfide minerogenic layers are extending through the bottom portion of the thick hydrothermal alteration zone. The finding has scientific significance as it may reveal the processes of the generation of hydrothermal deposits (*4).

Future perspectives

Through periodic monitoring of changes in the thermal fluid chemistry and studies on the diversity and function of sub-seafloor microbial communities, researchers will continue to explore variations in biomass and species composition of microbes active underneath the vents, and unlock the role and impact of their ecosystems on the hydrothermal environment.

The research scope will also include;

- detailed analysis of the cores,
- chemical and biological monitoring for the boreholes,
- composition of microbes and sulfide minerals.
- evidence for sub-seafloor biosphere, and
- boundary condition between the biotic and abiotic realms.

The genesis of hydrothermal deposits and the scale and characteristics of sulfide minerogenic layers in the Iheya field are also to be investigated.

Schedule of Chikyu

October 9 and 10	Open house of Chikyu at Nakagusuku Port, Okinawa (pre-registration required)(application closed)
October 11 - 14	Travel to Kobe Port
October 16	Open house at Kobe Port
October 19	Sets sail to Shingu Port, Wakayama
October 20 - 29	Material/equipment loading at Shingu Port
October 30 -	Embarks on Expedition 332

The above schedule is subject to change due to the weather or operational requirements.

***1 The Integrated Ocean Drilling Program (IODP)** is an international marine research drilling program dedicated to advancing scientific understanding of Earth by monitoring, and sampling subseafloor environments. Through multiple platforms, scientists explore IODP principal themes: the deep biosphere, environmental change, and solid Earth cycles. IODP has operated since October 2003, funded jointly by the Japan Ministry of Education, Culture, Sports, Science and Technology and the U.S. National Science Foundation. Additional support is provided by the 17-member European Consortium of Ocean Research Drilling, the People's Republic of China, the Republic of Korea, Australia, India, and New Zealand.

***2 Hydrothermally altered sulfate mineral**
A mineral containing sulfate anions formed through the interaction of hot water with the surrounding rocks.

***3 A caprock formation** is a non-permeable geological formation, which prevents fluids from migration up from below.

***4 Hydrothermal deposits**
When hydrothermal fluids are cooled and/or depressurized, they chemically precipitate solids from solution.

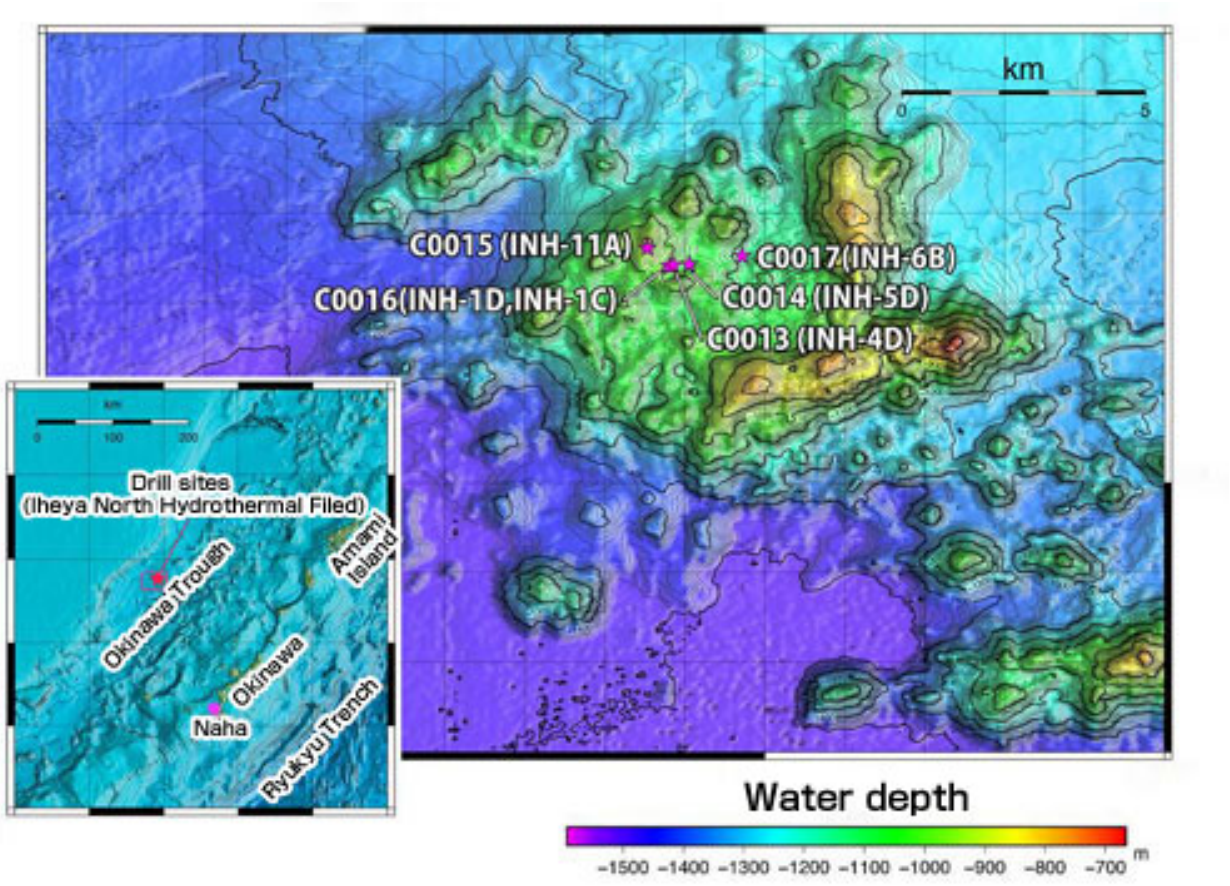

Figure 1. DEEP HOT BIOSPHERE study area and drill sites

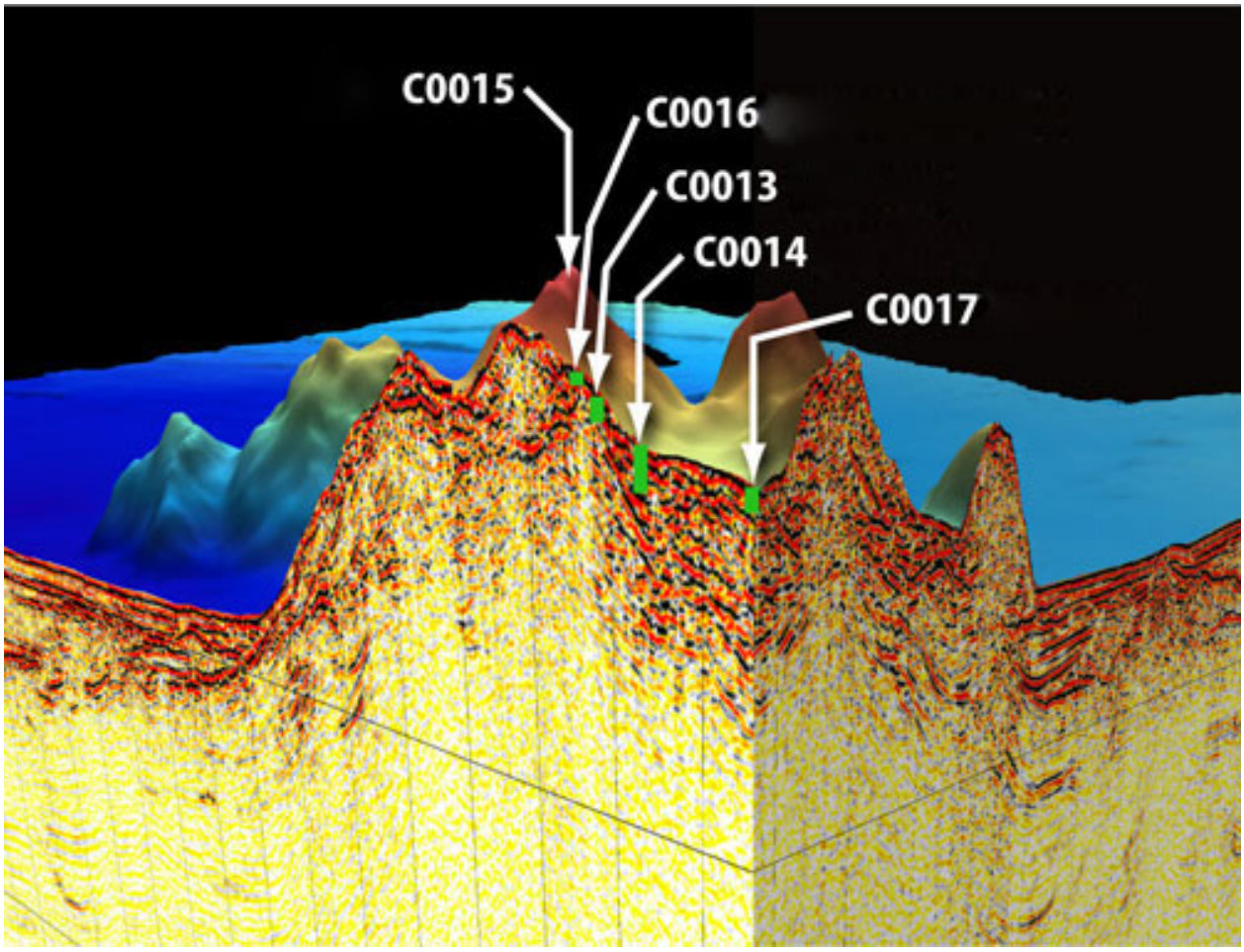

Figure 2. 3D Image of seafloor topography and sub-seafloor structure at Deep HOT BIOSPHERE sites

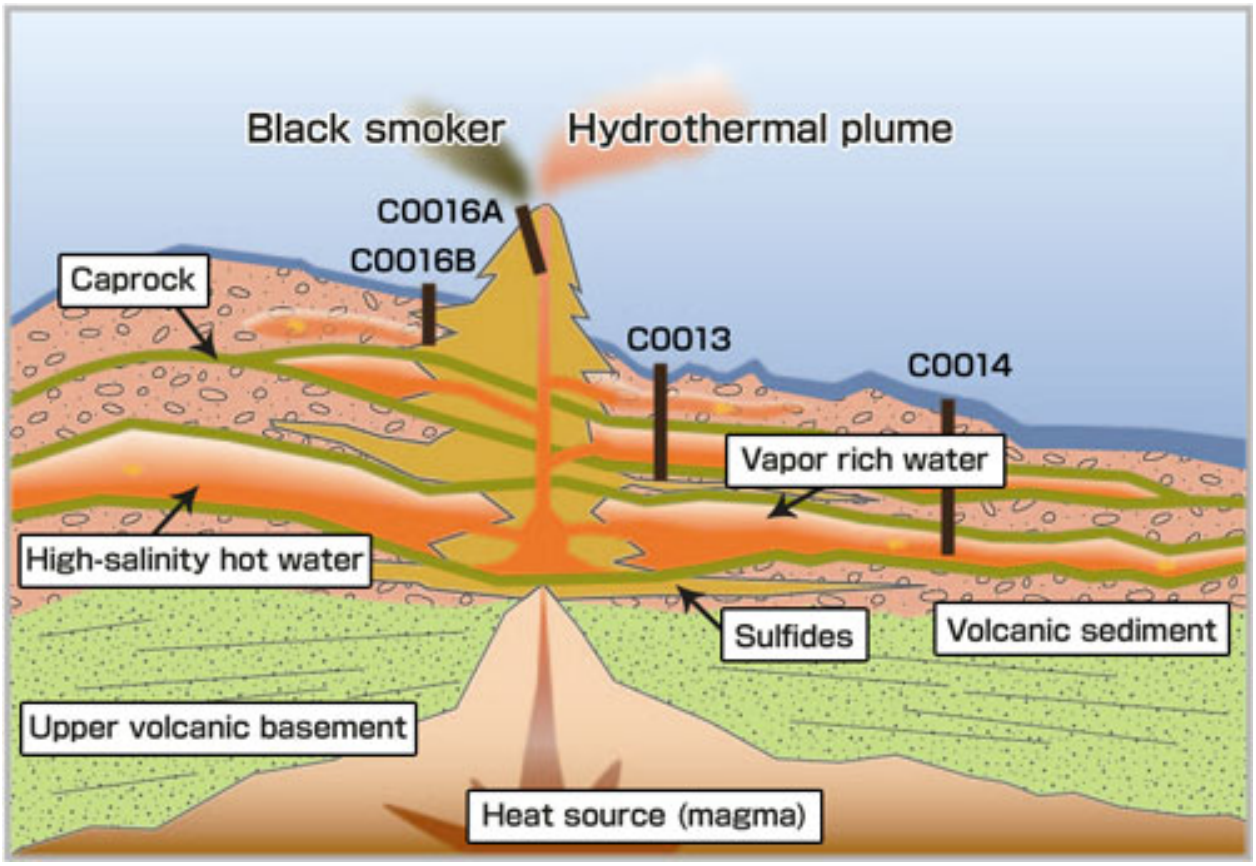

Figure 3. Sub-seafloor image of the eastern side of Iheya North hydrothermal system
Underneath the eastern side of the Iheya hydrothermal field, there are layers of caprock, which overlies the vast and deep expanse of hydrothermal fluid reservoir zone. The fluid in the upper portion of each caprock layer consists of lighter, vapor-rich water, whereas in the lower portion, there are heavier high-salinity waters.

Appendix

Drilling operation summary

Drill site	Hole name	Water depth (m)	Coring depth below seafloor (mbsf)	Cored length (m)	Summary of operations
C0013	A	1035.0	7.0	51.94	·Coring up to a depth of 54.3 meters below the seafloor (mbsf) to recover volcanic sediment containing hydrothermal minerals ·Drilling into the high-temperature hydrothermal fluid zone ·Hole E was fitted with casing pipes for future chemical and biological monitoring studies
	B	1035.5	9.5		
	C	1035.0	12.5		
	D	1036.5	35.5		
	E	1034.0	54.5		
	F	1035.1	7.5		
	G	1035.1	9.3		
C0014	A	1059.5	6.5	161.59	·Coring up to a depth of 136.7 mbsf to recover volcanic sediment containing hydrothermal minerals ·Drilling into the high-temperature hydrothermal fluid zone. ·Hole G was fitted with casing pipes for future chemical and biological monitoring studies
	B	1059.0	44.5		
	C	1060.0	6.5		
	D	1060.0	16.0		
	E	1060.0	19.0		
	F	1060.8	4.2		
	G	1059.8	136.7		
C0015	A	885.0	6.3	9.10	Coring up to a depth of 9.4 mbsf to recover volcanic sediment containing hydrothermal minerals.
	B	886.0	6.5		
	C	885.5	9.4		
C0016	A	982.0	18.0	0.00	Coring was attempted at an active hydrothermal mound, from the top to 18 mbsf.
	B	998.8	45.0	1.74	·Coring at the base of an active hydrothermal mound up to a depth of 45 mbsf. ·Recovery of volcanic sediment containing hydrothermal minerals. ·Drilling into the high-temperature hydrothermal fluid zone
C0017	A	1129.5	8.8	85.89	Coring up to a depth of 150.7 mbsf to recover volcanic sediment containing hydrothermal minerals.
	B	1129.5	18.3		
	C	1129.5	50.0		
	D	1129.5	150.7		
Total cored length				310.26	23 boreholes at 5 drill sites. Of them, 2 holes were fitted with casing pipes.

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