Diffusion observation of liquid CO_2 in the ocean by natural analogue

Background

Global warming is a problem that influences the international energy and environmental situation, and it is so serious a problem that it may alter whole ways of human life. It might be necessary to capture the carbon dioxide being generated by consumption of fossil fuel before discharging it into the atmosphere and to store it away from the atmosphere for longer time. CO_2 storage into the ocean and/or seabed geological formations has being studied as a possible option to mitigate the accumulation of anthropogenic CO_2 into the atmosphere. The key focus of technical research and development of environmental assessment for Carbon dioxide Capture and Storage (CCS) is understanding of dispersion of stored CO_2 in the ocean for CO_2 ocean sequestration, and detection/monitoring of CO_2 leakage from seafloor for CO_2 storage under seabed. In addition, impacts on the ocean environment including marine ecosystem should be assessed.

Through deep-sea hydrothermal activities, large amounts of elements including carbon as a form of CO_2 are discharged to deep-ocean. Deep-sea hydrothermal systems are suitable for the natural analogue *1 of a high CO_2 environment and diffusion process of CO_2 in the ocean.

Objectives

The purpose of this study is to confirm performance of the newly developed towing multi-layer monitoring system through observing hydrothermal-related liquid CO_2 dispersion with this system at the North-West (NW) Eifuku seamount (Fig. 1), submarine volcano, in southern Mariana Trough

Principal Results

1. Upgrade of towing multi-layer monitoring system

Torpedo-shaped submersible towing unit equipped with SSBL transducer, SSBL system, compass, clinometer, pressure gauge and sea anchor is towed below the sea surface by an observation ship, and performs sound communication between underwater transponder. The data from each transponder are forwarded with host CPU on a ship through wireless modem on surface unit. The torpedo-shaped submersible towing unit reduced vibration of the unit and improved the accuracy of underwater positioning (Fig. 2).

2. Diffusion observation of hydrothermal liquid CO2

Five transponder units containing transponder, in-situ pH/pCO_2 sensor and CTD were mounted on a towing wire at intervals of 50m. The mapping survey of low pH distribution was carried out with east-west direction trajectory line intervals of 0.5 nautical miles over a 3 x 3 nautical miles area at the NW Eifuku seamount using the grid navigation of the towing multi-layer monitoring system. Low pH and high CO_2 seawater derived from hydrothermal activity were detected above the summit of the seamount (Fig. 3).

3. Diffusion area of hydrothermal liquid CO2

At the summit of the NW Eifuku seamount, the low pH and high CO_2 seawater which originate in hydrothermal liquid CO_2 diffused only in the range of 100m in height, 200m across in the east-west direction and 40m across in the north-south direction. The pH variation in the diffusion ranged from 0.3 pH to 1.0 pH (Fig. 4).

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Future Developments

The scientific knowledge of detailed diffusion behavior of CO_2 in the ocean that is collected by natural analogue targeted at several hydrothermal systems will be reflected to research and development of CCS. The developed observation technologies will be applied to environmental assessment for detection/monitoring of stored CO_2 leakage from seafloor in CCS to sub-seabed.

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Reference

K. Shitashima, 2009, “Strategy of environmental assessment for CO_2 ocean sequestration – Diffusion observation of liquid CO_2 in the ocean –”, CRIEPI Report V08058 (in Japanese with English abstract)

*1 : Natural analogue: Observation technique by a similar natural phenomenon.

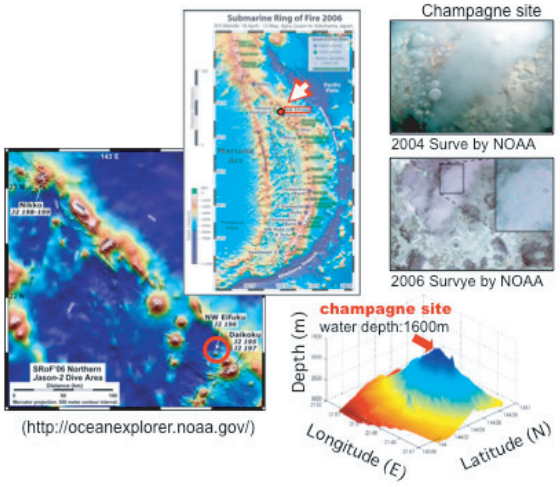

Fig.1 NW Eifuku seamount in the Mariana Trough.

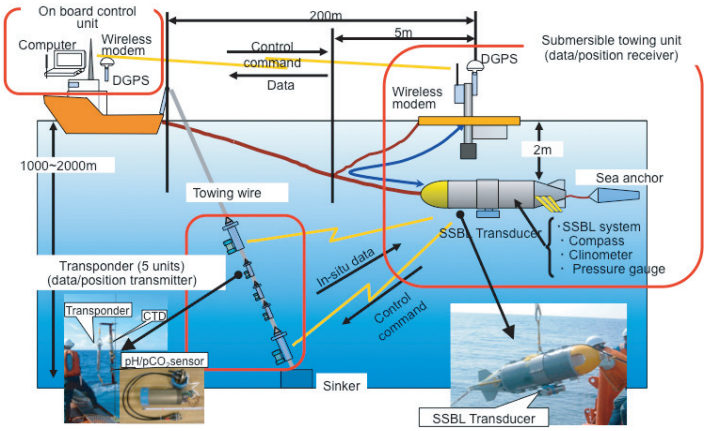

Fig.2 Towing multi-layer monitoring system. (This system can observe in five layers simultaneously.)

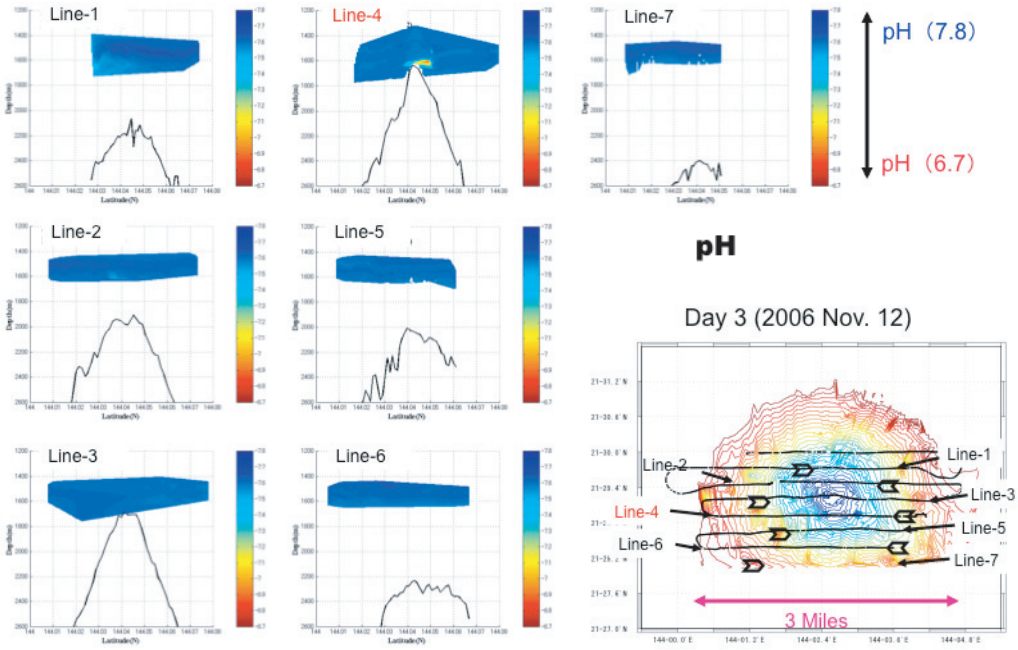

Fig.3 Vertical contour maps and observation lines (Line-1 – Line-7) on the NW Eifuku seamount. (Low pH and high CO_2 seawater was detected on Line-4 which went through the top of the seamount.)

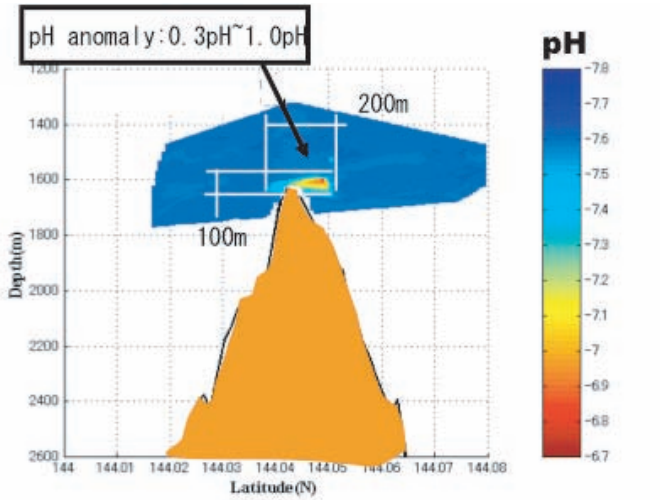

Fig.4 An enlarged drawing of vertical contour map of pH on observation line of Line 4. (The low pH and high CO_2 seawater (pH variation ranged from 0.3 pH to 1.0 pH) at the summit diffused only in the range of 100m in height, 200m in width of east-west direction and 40m in width of north-south direction.)