Strategy of Environmental Assessment for CO_2 Ocean Sequestration

Background

The CO_2 ocean sequestration research should focus on determining effectiveness as well as environmental consequences. To investigate the validity of CO_2 ocean sequestration, it is important that dissolution and dispersion behaviors of sequestrated CO_2 into the ocean are understood. In addition, ocean environmental impacts including that to marine ecosystem should be predicted. In other words, there is an issue of "establishment of environmental assessment technique" elucidated by sea-going observation and development of observation equipments and/or technique. We have been developing observation equipments and technologies for the purpose of assessing environmental impact of CO_2 ocean sequestration by sea-going observation.

Objectives

In order to assess the environmental impact of CO_2 ocean sequestration by sea-going observation, several technologies (in-situ pH/pCO_2 sensor, tracking neutral buoy system, towing multi-layer monitoring system, automatic elevator) were developed and the performance of these technologies was confirmed by sea trials.

Principal Results

1. High precision in-situ measurement of pH and pCO_2

"In-situ pH/pCO_2 sensor" is high precision in-situ measurement technology of pH and pCO_2 in seawater. The pH sensor used an ion sensitive field effect transistor (ISFET) for the pH electrode and a chlorine ion selective electrode (Cl-ISE) for the reference electrode. For the pCO_2 sensor, the pH sensor was sealed with a gas permeable membrane filled with the inner solution. This sensor can detect the changes of pH and pCO_2 derived from injected CO_2 precisely and rapidly (Fig.1 and Fig.2).

2. Water current and diffusion measurement at mid-ocean

"Tracking neutral buoy system" is seawater movement observation technology in mid-depth of the ocean. This system can observe the seawater movement of the CO_2 injection layer in Lagrangian method by tracking the buoy which installed in-situ sensor and transponder together with the injected CO_2 (Fig.3).

3. Short-term dilution effect of injected CO_2 to mid-ocean

"Towing multi-layer monitoring system" is diffusion behavior observation technology in mid-depth of the ocean. This system can observe the diffusion behavior of injected CO_2 by towing several in-situ sensors and transponders in the curtain-shaped CO_2 plume (Fig.4).

4. Long-term monitoring of dilution and diffusion behaviors of CO_2

"Automatic elevator" is time-series observation technology of diffusion behavior. This equipment can observe diffusion behavior of injected CO_2 in Eulerian method by going up and down the buoy which installed the in-situ pH/pCO_2 sensor and depth sensor.

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Future Developments

Deep-sea hydrothermal vent fluids are highly enriched in CO_2 and the CO_2 rich fluids are released into the ocean as a hydrothermal plume. Deep-sea hydrothermal systems are suitable for natural analogue *1 of CO_2 dispersion in the ocean. By applying the hybrid observation system (Fig.5) to the deep-sea hydrothermal systems (or the small scale CO_2 injection experiment) as new cost-effective observation techniques, it is expected that the dispersion behavior of the sequestrated CO_2 into the ocean will be understood and the assessment for environmental impact of the CO_2 will become possible.

Main Researcher: Kimonori Shitashima, Ph. D.,
Senior Research Scientist, Environmental Chemistry Sector, Environment Science Research Laboratory

Reference

K. Shitashima, 2006, "Strategy of environmental assessment for CO_2 ocean sequestration Development of highly precise in-situ pH/pCO_2 sensor-", CRIEPI Report V05036 (in Japanese)
K. Shitashima and T. Ohsumi, 2006, "Strategy of environmental assessment for CO_2 ocean sequestration - Development of observation equipments for behavior of sequestrated CO_2 in the ocean-", CRIEPI Report V05037 (in Japanese)

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*1 : Natural analogue: Natural analog is an experimental technique for a similar natural phenomenon for the field experiment that enforcement is difficult.

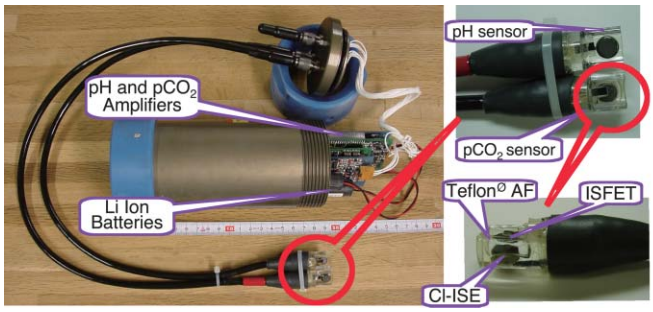

Fig.1 situ pH/pCO_2 sensor

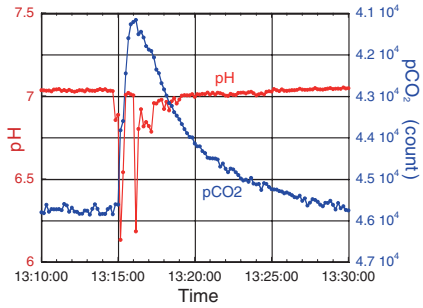

Fig.2 In-situ responsivity of pH/pCO_2 sensor

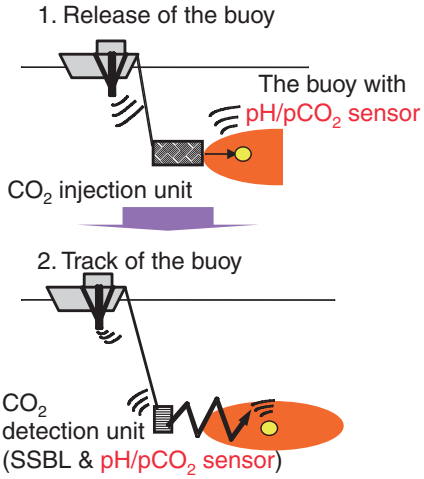

Fig.3 Tracking neutral buoy system

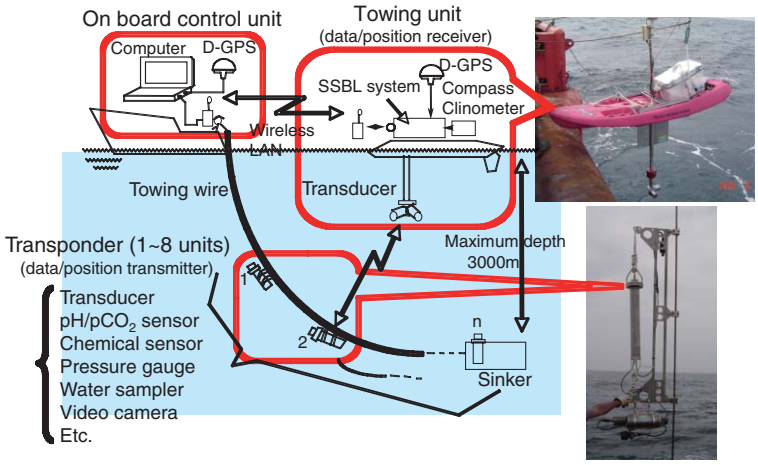

Fig.4 Towing multi-layer monitoring system

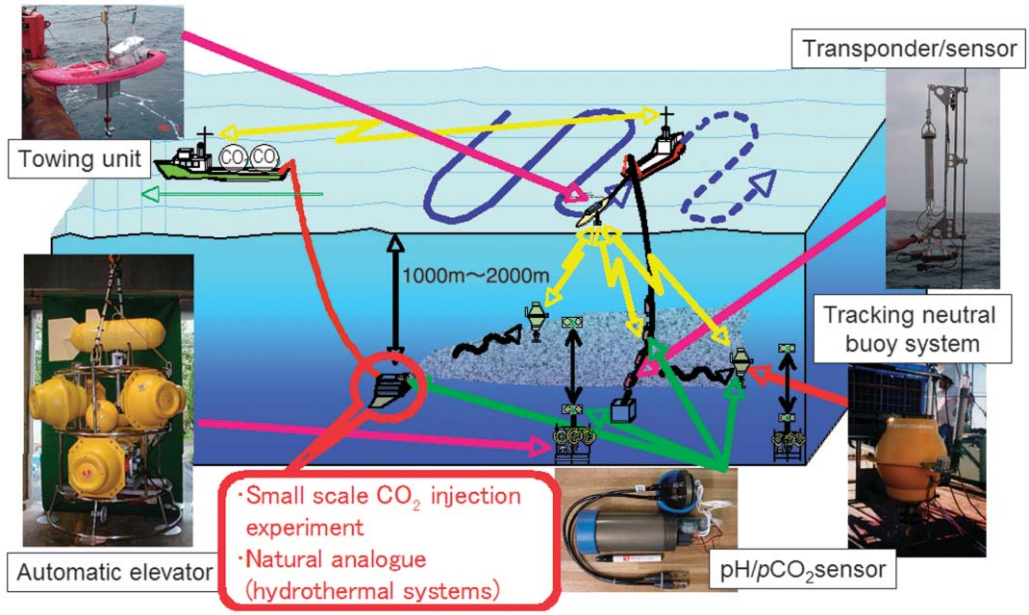

Fig.5 Observation strategy of environmental assessment for CO_2 ocean sequestration

Observation of diffusion behavior of injected CO_2 in mid-depth of the ocean is performed by using the hybrid system which integrate the tracking neutral buoy system with the towing multi-layer monitoring system. The pH/pCO_2 sensor is installed to the automatic elevators, each transponder of the towing multi-layer monitoring system, CO_2 injection equipment and plural units of the tracking buoy, and measures in-situ pH and pCO_2. These data can be monitored by sound communication in real time on board. Several automatic elevators are deployed in the CO_2 injection area and measure the temporally and spatially continuous diffusion behavior of the injected CO_2.