# Natural Laboratory for the Development of Monitoring Strategy for Ocean CCS

Kiminori. Shitashima

Associate Professor
$CO_2$ Sequestration and Storage Division

The $CO_2$ storage into the ocean and/or the seabed geological formations has being studied as one of possible options to mitigate the accumulation of anthropogenic $CO_2$ into the atmosphere. The carbon dioxide capture and storage (CCS) research should focus on determining the effectiveness, as well as environmental consequences. It is important that dissolution and diffusion behaviors of $CO_2$ in the ocean are understood. In addition, monitoring system for ocean environmental impact including marine ecosystem should be established. Accordingly, it might be the most effective method to perform a small scale $CO_2$ injection experiment on the ocean. However, because of our inadequate knowledge about environmental influence of the injected $CO_2$ to the ocean, even a small scale $CO_2$ injection experiment so far, failed to obtain a public consensus.

Large amounts of $CO_2$ are being supplied to the ocean from the seafloor as a natural phenomenon at deep-sea hydrothermal systems (hot spring at seafloor). Hydrothermal fluids are highly enriched with $CO_2$ and show low pH (around pH 2 to 3) relative to seawater. This $CO_2$ is taken up from the basalt by the fluid during high temperature seawater-magma interaction. In the Okinawa Trough and Mariana Trough, liquid $CO_2$ is emitted from hydrothermal vents at about 1500m depth, and $CO_2$ gas bubbles are erupted from seafloor at 100-200m depth in the Kagoshima Bay and 20m depth in the Taketomi Island in Okinawa. Dissolution of liquid $CO_2$ during ascent of $CO_2$ droplet and diffusion of low pH seawater (pH 6.4 to 7.3) were observed at the Hatoma Knoll in the Okinawa Trough. The $CO_2$ droplets emitted from the seafloor dissolve slowly into the ambient seawater while ascending, but changes in pH and $pCO_2$ near the rising $CO_2$ droplets are small. The in-situ pH mapping revealed that the discharged liquid $CO_2$ does not cause widespread pH depression in the ambient environment. At the NW Eifuku submarine volcano in the Mariana Trough, the low pH plume (pH 6.7 to 7.4) derived from hydrothermal liquid $CO_2$ was detected in 100m high and 200m wide area above the summit of the volcano. The result of $CO_2$ gas bubbles mapping survey at the Wakamiko Caldera in the Kagoshima Bay indicated only localized pH depression (pH 6.4 to 7.7) below 120m depth because $CO_2$ in gas bubbles dissolved to seawater during ascent of gas bubbles. At shallow hydrothermal system off Taketomi Island, tiny area (10m x 10m) at $CO_2$ venting site showed low pH environment (pH 6.3 to 7.6).

Deep-sea hydrothermal systems are optimum as a natural laboratory (natural analogue) for a high $CO_2$ environment in the ocean. Observation of the hydrothermal $CO_2$ would provide an opportunity for understanding the physicochemical behavior and diffusion process of $CO_2$ in the ocean. Natural analogue study contributes to the development and verification of efficient monitoring system for the ocean CCS. Furthermore, the information on the hydrothermal vent ecosystem is important for research of environmental impact of the ocean CCS.