Natural analogue for behavior of liquid CO2 in the ocean

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The CO2 ocean sequestration research should focus on determining the effectiveness, as well as environmental consequences. It is important that dissolution and dispersion behaviors of sequestrated CO2 to the ocean are understood. In addition, ocean environmental impact including marine ecosystem should be predicted. Accordingly, it might be the most effective method to perform a small scale CO2 injection experiment on the ocean. However, because of our inadequate knowledge about environmental influence of the injected CO2 to the ocean, even a small scale CO2 injection experiment so far, failed to obtain a public consensus.

Through deep-sea hydrothermal activities, a large amount of elements including carbon as a form of CO2 are discharged to deep-ocean. The hydrothermal fluids are highly enriched in CO2 and show lower pH (about pH2-3) relative to seawater. Deep-sea hydrothermal systems are suitable for the natural analogue of a high CO2 environment in the ocean. The observation of the hydrothermal CO2 would provide the opportunity for understanding the physic-chemical behavior and diffusion process of CO2 in the ocean. Furthermore, the information on the hydrothermal ecosystem in the high CO2 environment is important for an environment impact assessment of the CO2 ocean sequestration. The objectives of this paper are to present data on the behavior of a rising CO2 droplet and the chemical environment of surrounding natural liquid CO2 from the hydrothermal systems. This study was financially supported by the RITE.

The Hatoma Knoll in the Okinawa Trough is the caldera-shaped topography. The CO2 droplets were emitted from the bottom of the caldera (1520m depth). The CO2 droplet (0.5ml) contains CO2 of 95-98%, H2S of 2-3% and other gas species. The observations of behavior of natural CO2 droplets were carried out in the deep-sea hydrothermal system at the Hatoma Knoll on 2004 and 2005.

The rising CO2 droplets were tracked by an ROV Hakuyo 2000 and depth, temperature, salinity, pH and pCO2 in seawater near the CO2 droplets were measured during their ascent by using CTD and in-situ pH/pCO2 sensor. A monitoring box, 30 cm wide, 15 cm deep and 100 cm long, open to the ocean at top and bottom, was used for making easy to track the rising CO2 droplet. The ROV was operated so that a CO2 droplet entered in the monitoring box near seafloor. The behavior of the rising CO2 droplet was observed with an HDTV deep-sea camera on the ROV. The ROV was ascended while maintaining a CO2 droplet within a field of vision of the deep-sea camera. In-situ data of temperature, conductivity, depth, pH and pCO2 near the CO2 droplet were recorded during the observation. Several tracking observation of rising CO2 droplet was carried out.

The rise rate and size of the CO2 droplets decreased during their ascent in water column (from 1470 m to 700 m depth). The CO2 droplets became small CO2 clathrate while rising, and the rising clathrate materials were found to disappear at 701 m depth (779 m above the bottom). These results suggest that the rising liquid CO2 dissolves gradually in ambient seawater and completely disappears around 700m depth in the ocean. Although the pH just above the sea floor CO2 vents showed pH 5, the pH depression and pCO2 increase in seawater surrounding the rising CO2 droplets were not observed, and the anomalies of pH and pCO2, low pH and high pCO2, near vents were recovered in a normal value within several ten meters from seafloor. Even though the rising liquid CO2 dissolves gradually in ambient seawater, these results indicate that pH depression by dissolution of liquid CO2 does not occur in the ocean. The mapping survey at intervals of 100 m in an area 400 m square was carried out with four layers. These results demonstrated that pH depression was localized at the CO2 venting site.