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Microbial activity in deep-sea hydrothermal ecosystem

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Ecosystem in deep-sea hydrothermal field is sustained by chemolithoautotrophic microorganisms, which use reduced chemicals as energy source and produce organic materials from CO2. As was shown in photosysthetic ecosystems, many heterotrophic microorganisms have also been found in the hydrothermal ecosystem, and they assumed to play a significant role in carbon cycle. However, little is known about the amount of carbon transfer in the hydrothermal microbial ecosystems. In this study, we developed and examined several sample collection and incubation methods to clarify carbon transfer pathway in microbial ecosystems using MAR with radio isotope tracers at a single cell level.
Hydrothermal mixing water samples were collected from a mixing zone of hydrothermal fluid and seawater at Hatoma Knoll hydrothermal field in the mid Okinawa trough and used for incubation experiments. Three incubation methods were examined for 4 different carbon sources, e.g. [14C] amino acid mixture, [14C]glucose, [14C]methanol, sodium[14C]bicarbonate. The first incubation was conducted under the condition of keeping in situ pressure (Keeping Pressure: KP) using pressure-tight sampler bottle. The second and third incubation samples were subsampled on board after sample retrieval and then the sub-samples were incubated with addition of in situ pressure (Adding Pressure: AP) and at atmospheric pressure (Ordinary Pressure: OP). 14C-incorporated cells were visualized and determined by microautoradiography (MAR) and carbon uptake rate was determined using liquid scintillation counter.
After 24 hour incubation, uptake of RI substrates by microbes was found under OP with [14C] amino acid and [14C]glucose, and under KP with [14C]amino acid, [14C]glucose and [14C] bicarbonate, through both MAR and liquid scintillation counter analysis. Especially high amount of [14C]amino acid and [14C]glucose were incorporated under anaerobic/microaerobic condition after 48 hours OP incubation. Microbial responses under OP, AP, and KP incubations showed importance of incubation condition to investigate environmental microbial activities. These results indicated that activity of microbial community is very hard to detect by on board incubation experiment. This may be because decrease of microbial activity and cell body during sample treatment and preservation under RT and atmospheric pressure for more than 3 hours. In addition, concentration of dissolved reduced gas such as methane and hydrogen, is important for autotrophs. Our result showed that approximately 30% of the hydrothermal microbial community in the mixing zone were autotrophic, whereas the 40% of the microbial community were heterotrophic. These indicated that the heterotrophic microbes play an important role in carbon cycle in hydrothermal environment.

Keywords: Deep sea hydrothermal vent, microbial ecosystem, in situ incubation, carbon cycle, 14C tracer, Microautoradiography