Ecology and stable isotope composition of benthic foraminifera associated with cold seeps on the Hidaka Trough, northwestern Pacific

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Benthic foraminifera at cold seeps on the Hidaka Trough, northwestern Pacific were studied to investigate the effects of methane on the geochemistry and faunal characteristics of benthic foraminifera assemblages and to discuss potential applications of foraminifera for reconstruction of methane release in the past and present. Sediment cores for this research were collected from eight chimney sites and one reference site with gravity corer in July 2015. Calcareous forms dominate benthic assemblages, accounting for 90 percent or more of the benthic populations for most samples. Results from Rose Bengal staining method indicate that certain species inhabit seep sites in the study area. *Rutherfordoides cornuta*, which is related to high methane gas content of the sediments and reported as methanophilic taxa from methane seepages at Sagami Bay (Akimoto et al., 1994; Kitazato, 1996), found alive (cytoplasm containing specimens) within surface sediments at four chimney sites in our study area including cores at the center of chimney. Other calcareous foraminiferal assemblages associated with chimney sites were typically infaunal species including *Brizalina pacifica*, *Bolivina spissa*, *Chilostomellina fimbriata*, *Globobulimina auriculata*, *Nonionella globosa*, *Nonionella stella*, *Stainforthia fusiformis*, and *Uvigerina akitaensis*, which can inhabit below water-interface and are also abundant in organic-rich oxygen-depleted environments. Geochemical analyses of living (stained) benthic foraminifera in our research sites doesn't show highly negative $\delta^{13}C$ values comparable to those fossil (unstained) benthic foraminifera that are reported from seep sites such as the Gulf of Mexico (Sen Gupta and Aharon, 1994) or Monterey Bay (Martin et al., 1999); however differences in $\delta^{13}C$ values for living benthic foraminifera of a given species were observed within a single core or between cores at chimney sites, which are unusual. For instance chimney site cores contain live specimens of *B. spissa* with $\delta^{13}C$ values ranging from -0.43‰ to -1.07‰, -0.71‰ to -1.97‰, and -0.37‰ to -0.94‰, respectively. In contrast, at reference core the $\delta^{13}C$ composition of *B. spissa* varies little and remains approximately constant around -0.70‰ over the length of the core. Variable carbon isotope values are also evident in other species such as *U. akitaensis*. These results suggest that $\delta^{13}C$ values of foraminifera tests are influenced by methane seepage and different pore-water chemistry. Therefore, variations in isotopic composition can suggest temporal variations in seep activities and the differences in carbon isotope values will be expect to increase with the activity of the seeps. A good comprehending on ecology and stable isotope composition of modern benthic foraminifera at cold seeps may help identify paleo-seeps and will enhance our knowledge of climatic and oceanographic changes. This study was conducted as a part of the shallow methane hydrate exploration project of METI.

Keywords: Benthic foraminifera, Cold seeps, Hidaka Trough, Methanophilic taxa, Northwestern Pacific, Stable isotopes

