Distribution and Isotope geochemistry of living benthic foraminifera from cold seep environments of Hidaka Trough

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This study present ecological and isotopic data on living benthic foraminifera sampled from *Calyptogena*, mud volcano and aragonite sites in cold seep area of Hidaka Trough, northwestern Pacific. Sediment samples for this research were collected with three different methods including grab sampler, pilot corer and ROV push corer during Daiichi Kaiyomaru expedition in July 2017. Living benthic foraminifera standing stocks range between 2 per gram at mud volcano site (pilot 4) and 138 per gram at *Calyptogena* site (ROV push core 3B). Shannon Index (*H'*) is minimal (1.20) at *Calyptogena* site (Pilot 1) and maximal (3.77) at aragonite site (ROV push core 6), while Evenness indices only show minor variability between three sites. Perforate calcareous species dominate benthic foraminifera faunas at all sites, accounting for >93% of the living community. Their contribution is highest at *Calyptogena* site, where they account for 99% of benthic population. Agglutinated foraminifera represent between 0.3% and 6% of foraminifera assemblages. Of the perforate species, *Stainforthia fusiformis*, *Nonionella stella*, *Nonionella globosa*, *Nonionella labradorica*, *Uvigerina akitaensis*, *Elphidium batialis*, *Globobulimina auriculata*, *Chilostomellina fimbriata*, and *Brizalina pacifica* are dominant at all sites. The isotope composition of the dissolved inorganic carbon (DIC) at three sites in Hidaka area indicates anaerobic oxidation of methane by bacteria with $\delta^{13}C_{DIC}$ values as low as -49‰ in the upper part of the sediments. The isotope data for living and dead benthic foraminifera in each site showed that each species has its own range of isotope signatures. In addition, differences in $\delta^{13}C$ values for living benthic foraminifera of a given species were observed within a same location or between different locations. For instance, live specimens of *G. auriculata* showed $\delta^{13}C$ values ranging from -0.95‰ at mud volcano site (Grab 1707) to -2.56‰ at *Calyptogena* site (Grab 1705B). These differences in $\delta^{13}C$ values also observed in other species such as *U. akitaensis*, *B. spissa*, *C. fimbriata*, *E. batialis*, and *N. labradorica*. In spite of extremely low pore water $\delta^{13}C_{DIC}$ values (-4 to -49‰) in the study area, the $\delta^{13}C$ values of living benthic foraminifera are not significantly lighter than those reported previously in non-seep sediments, and are within the range expected from local organic matter decomposition (0 to -3‰). However, carbon isotope value of fossil foraminifera found deeper in the sediments showed more negative than living $\delta^{13}C$ values. For example, fossil specimens of *E. batialis* at *Calyptogena* site (ROV push core 3A) showed $\delta^{13}C$ value that were 5.95‰ lighter than its living $\delta^{13}C$ value. In addition, the $\delta^{13}C$ signatures of dead or recently dead foraminifera species (*U. akitaensis*, *C. fimbriata*, *N. labradorica*, *E. batialis*) in pilot 1 at *Calyptogena* site were extremely depleted as low as -33.95‰. The apparent $\delta^{13}C$ disequilibrium between living benthic foraminifera calcite and pore water DIC might be suggests that in seep area of Hidaka Trough, living benthic foraminifera mostly calcify during periods of low methane discharge or during intermittent of seawater flow into the sediments and overprinting of the original isotopic composition of foraminifera by overgrowth or recrystallization at or below the sediment surface might cause extreme ^{13}C depletion observed in fossil foraminifera. Heterogeneity of isotopic values may result either from genetic or biological differences between the populations or from differences in environmental isotopic influences such as pore water differences. Understanding the processes involved in the disequilibrium between benthic foraminifera isotopic composition and the pore water DIC where they were found will provide reliable proxies for paleoceanographic reconstructions.

Keywords: Living benthic foraminifera, Cold seeps, Hidaka Trough, Isotope geochemistry

