Ecosystem modeling around active seafloor methane seepages

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There are generally two methane passes in conjunction with the active natural cold seepages on seafloor as schematically shown in Fig. 1. The coupled anaerobic oxidation of methane and anaerobic sulfate reduction, and the sulfur oxidation in the bacterial mats and immobilization thereafter in the sediment layer and on the seafloor are the first one. Through the first pass, calcium and organic carbonates are formed with biological and chemical processes from the methane. The other one is the direct methane bubbling into the water column. Through the latter pass, organic carbonate is formed with biological oxidizing and small amount of the methane goes out to the atmosphere.

In this study, the following five processes are numerically created and connected as an ecosystem model around active natural cold seepages. The direct supply source and mechanism of methane for the cold seepages has not yet been clarified, though some models have been proposed. Here, in this study, in order to integrate the seafloor and water column methane consumption processes, a tentative methane supply mechanism is created and connected with the coupled anaerobic oxidation of methane and anaerobic sulfate reduction.

Because CANDI (Carbon And Nutrient Diagenesis) (Boudreau, 1996) and C.CANDI (Luff et al., 2004) are well coordinated biogeochemical and bicarbonate process models, the authors selected them as the base of the coupled anaerobic oxidation of methane and anaerobic sulfate reduction.

The sulfur oxidization, following the coupled anaerobic oxidation of methane and anaerobic sulfate reduction, occurs in seafloor bacteria mats. The chemosynthesis-immobilization communities such as tubeworms and clams are the other important members in the seafloor ecosystem around the active natural cold seepages. Endosymbiont sulfur oxidizing is considered to be the main energy source of the communities. Both the two activities are included in the sulfur oxidizing and immobilization process.

After the bubbling from seafloor, the methane bubble jet blows up in the water column due to the buoyancy caused by the density difference between the ambient water. Then the dissolution and dispersion process with methane oxidizing occurs in the water column. Except the biological methane oxidizing, the other processes are classified as physical ones under 3-dimentional salinity, temperature, depth (STD), and current structure.

Applying existing field observation data and assumed conditions, some preliminary calculations were conducted. The results show a reasonable similarity with the observed results.

In order to estimate total methane flux in a certain area, both approaches from the seafloor and water column methane consumption process units are necessary. A systematic and strategic measurement project, which includes the simultaneous measurement of methane concentration distribution and current profile in water column, the seafloor sediment sampling for biological and chemical analyses, and visual observation of the seafloor to assess the biomass of chemosynthetic communities, are desired.