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Non-steady Growth Modeling of Anaerobic Consortium of Microorganisms around Methane Seepage

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ABSTRACT

As a part of fundamental understanding of ecosystem functions around seafloor methane seepage, the non-steady growth modeling of anaerobic oxidation of methane and anaerobic sulfate reduction by consortium of microorganisms is studied numerically. The model and results of preliminary test calculation are introduced.

KEY WORDS: anaerobic methane oxidation; anaerobic sulfate reduction, AOM, chemosynthetic ecosystem; methane seepage; numerical model.

INTRODUCTION

Natural cold seepages are characterized as rapid upward transports of methane from deeper parts of geological structures to the seafloor. Thermogenic and/or biogenic methane generated in deep strata moves up to seafloor, and major part of methane are consumed by microorganisms living in anoxic marine sediments. When the supply of methane is very large or rapid, remaining unconsumed methane escapes from the seafloor to the water column.

Methane itself has a considerable impact on the greenhouse effect, if it is released into the atmosphere in the global carbon cycle. It is reported that methane emission from oceans is ca. 5.6 % in percent of total emission (Lelieveld et al. 1998, cited after the Intergovernmental Panel on Climate Change (IPCC) 2001), but detailed numerical explanation of methane emission and consumption in ocean has not been cleared yet.

In Japan, the potential use of natural methane hydrate as an energy resource has been highlighted, and a national R&D project named MH21 to locate deposits and to develop exploitation technologies has been conducted (http://www.mh21japan.gr.jp/english/index.html). Since there are less domestic oil and natural gas resources in Japan, the highly attractive possibility for energy resource and the many potential areas in ocean around Japan are the alternative reasons of the project. Less CO_2 discharge from methane compared with coal, oil and conventional natural gas when the same calorie value we get is considered as the advantage for energy resource. However, because methane hydrate distributes in shallower sediment layer in ocean floor, accidental leakage of methane through the drill holes themselves and natural fissures and faults may occur while we utilize methane hydrate. Therefore, it is necessary to estimate the behavior in the marine environment after the leakage, if we want to use methane hydrate as energy resource.

The methane from accidental leakage into near seafloor will be consumed by the same type ecosystem like the natural cold seepage. However, it is expected to take much time for the creation of steady state in the methane consumption. Our final goal is to create a new numerical ecosystem model to estimate mass balance in the marine environment under non-steady condition and apply the model for the environmental assessment of the methane hydrate exploitation.

For the first step of understanding the non-steady reaction, a growth modeling of anaerobic oxidation of methane (AOM) and anaerobic sulfate reduction by consortium of microorganisms is studied. The present study has been a part of MH21 project since 2006 in creating a model to assess the environmental impacts for the future exploitation.

OVERVIEW OF ECOSYSTEM MODEL

Our model is constructed from 3 main processes as schematically shown in Fig. 1: (1) Methane supply process; (2) Ecosystem process; (3) Water column process.

Methane supply process

Though some models were proposed (Tryon et al., 2002; Coffin et al., 2003), the methane supply source and mechanism for the cold seepages has not yet clarified. In our study, in order to integrate the seafloor and water column methane consumption processes, a tentative methane supply mechanism has been created. Three routes, such as for bacterial mat field and bivalve field ones under low flux and direct bubbling one into water column under high flux, are assumed (Yamazaki et al., 2008). The advanced diagenesis process introduced in this study is also effective during the three routes through the sediment layer from the