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Preliminary Modeling of Chemosynthetic Ecosystem around Methane Seepage

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ABSTRACT

A mass balance ecosystem model of a chemosynthetic community around natural cold seepages in sediment layer and on the seafloor has been created numerically. Though the model is in preliminary form, the mechanism and functions necessary to support the community are fundamentally solved. A quantitative evaluation of the ecosystem may be possible given sufficient seafloor observation and monitoring.

KEY WORDS: Anaerobic methane oxidation; Chemosynthetic ecosystem; Cold seepage; Gas plume; Methane; Numerical model.

INTRODUCTION

Natural cold or hydrothermal 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 sediments moves up to the seafloor, and most of the methane is consumed by microorganisms living in anoxic marine sediments. When the supply is large or rapidly increasing, the remaining methane escapes from seafloor and is aerobically oxidized in seawater.

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 accounts for ca 5.6% of total methane emissions (Lelieveld et al. 1998, cited after IPCC 2001), but there has been no detailed numerical explanation of methane emission and consumption in the oceans. Our goal is to create a new numerical ecosystem model in the marine environment and to estimate mass balance in a methane seepage system using the existing data from chemical analysis.

In Japan, the potential use of natural methane hydrate as an energy resource has been highlighted, and a national R&D project to locate deposits and to develop exploitation technologies has been conducted (http://www.mh21japan.gr.jp/english/index.html). The present study was part of a project in 2006 to create a model to assess the environmental impacts of future exploitation.

OVERVIEW OF ECOSYSTEM MODEL

Our model is constructed from three main processes as schematically shown in Fig. 1: (1) a methane supply process, (2) an ecosystem process, and (3) a water column process.

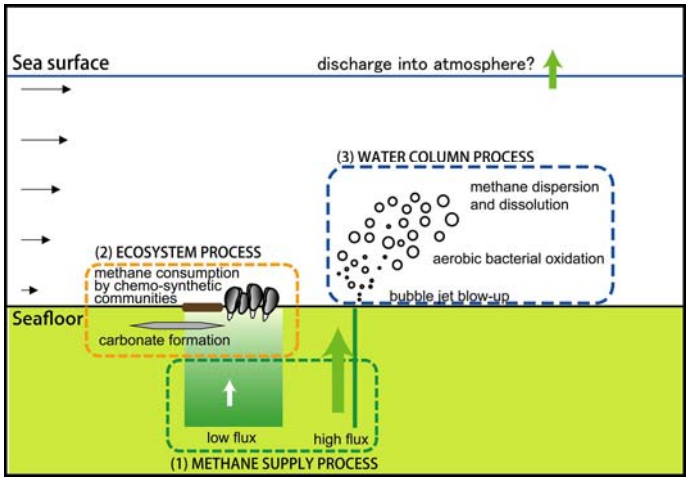

Fig. 1 Schematic outline of mass balance ecosystem model around seafloor natural cold seepage and its components

Methane supply process

It is considered that when a large amount of methane rapidly moves along a pass, such as a fault, methane is supplied directly to the seafloor with little consumption. Three routes are assumed, and the advanced diagenesis process is also effective during the passages through the sediment layer from the free-gas zone to the seafloor surface.

Ecosystem process

The CANDI (Carbon And Nutrient DIagenesis) numerical model was developed by Boudreau (1996) to simulate biogeochemical processes