

Reactive transport modeling to determine methane sources of natural gas hydrates with constraint of geochemical observation

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The sources of methane forming natural gas hydrate originate from two aspects, biogenic and thermogenic gas. Biogenic gases are generated from methanogens in shallower sediments with lower temperature, and are mainly consisted of pure CH₄. Thermogenic gases come from the organic decomposition of fossil matter under high temperature condition, including abundant CH₄ and other hydrocarbons. The source of methane significantly affects the accumulation of hydrate. Determining the sources of methane forming hydrates is critical for assessing natural gas hydrate exploration potential, as well as exploiting hydrates. The formation of methane source in marine sediments on a large time scale is a process of various intertwining chemical reactions (including biogeochemical reactions), which are difficult to quantitatively investigated without the help of numerical tools. This study aims to provide a portable solution for quantifying contribution of methane sources via numerical simulations with the constraint of site-specific geochemical data. To numerically describe the complex processes of biogenic and thermogenic methane productions, an integrated simulation package, TOUGH+Hydrate+React (TOUGH+HR), was developed by coupling reactive transport, biodegradation and deposition of organic matter, hydrocarbon generation with behaviors of hydrate-bearing system. Based on the observed data from site SH2 in the South China Sea, a growing 1-D column model (Fig.1) was constructed, and hydrate accumulation with various methane sources were simulated using the developed TOUGH+HR tool. The simulated results indicate that the source of methane forming hydrates at the SH2 site is a mixture of biogenic and thermogenic methane. By constraining the simulations using the measured data, the ratio of biogenic methane to thermogenic methane was estimated to be about 1:3. With this mixed source of methane the simulated results matched the observed data well, including the spatial distributions of hydrate saturation and remained total organic carbon (TOC), the location of interface between dissolved methane and sulfate. The methodologies reported in this study can be applied to further understand the complex processes of hydrate accumulation, associated geochemical responses, and the carbon cycle in submarine sediments.

Keywords: Reactive transport modeling; Biogeochemistry; Methane source type; Natural gas hydrate

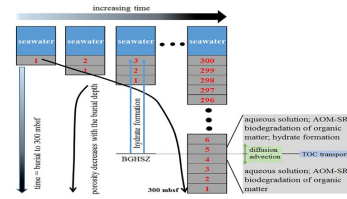


Fig.1 Growing conceptual model used to depict the sedimentation

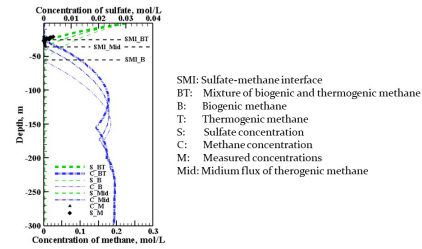


Fig.2 Profiles of sulfate and methane vs. depth with different methane sources