Geochemical evidence from core 973-2 and 973-4 for methane activity near Jiulong methane reef in the northern South China Sea

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Abstract: The Jiulong Methane Reef, located on the northern slope of South China Sea (SCS), is characterized by a large number of features, such as bottom simulating reflections (BSRs) and authigenic carbonates, which are indicative of methane seepages occurring currently as well as in the past. This area also shows evidence of considerable hydrocarbon source underneath the seabed. For a better understanding of methane seep activities, a 673-cm-long gravity core (973-2) and a 1375-cm-long gravity core (973-4) were retrieved in this area for in-depth analysis. The chronology of two cores were established by AMS^{14}C dating, and sedimentary events since the last glacial period were recorded. The results showed abnormally low abundance of benthic foraminifera and oxygen-depleted conditions in the lower part of the core 973-2 from 673 to 350cmbsf according to benthic assemblages and trace metals. Major elemental barium (Ba), bromine (Br), and titanium (Ti), which serve as proxies of paleoproductivity, organic contents, and terrestrial supply, respectively, were found to make little contribution in $CaCO_3$ content. However, regardless of the factors mentioned above, $CaCO_3$ content still remained high in the lower part of core, indicating the presence of authigenic carbonates. In one of the sections, molybdenum profile showed enrichments, which is closely related to methane seeps. The results indicate that the core 973-2 has experienced multi-episodes of methane seep events with anaerobic oxidation of methane (AOM) and aerobic oxidation occurring alternatively in the last glacial period. The core 973-5 has a shallow sulfur-methane interface at ~9 m depth below the sea floor (bsf). Negative carbon isotopic deviation of planktonic foraminifera ($\delta^{13}C = -1.34‰$) has been recorded at Site 973-4, and may reflect surges of cold seep fluids on a millennial scale, and epigenesis played a negligible role in foraminiferal shells' negative $\delta^{13}C$. Compared with non-seep site, Site 973-4 has more negative $\delta^{13}C$ of benthic foraminifera in deposits from the last glacial maximum (LGM, or early Holocene) but equivalent $\delta^{13}C$ values at present. During the last glarcial period, cold-seep foraminiferal assemblages had lower diversity, oxygen levels and Shannon-Wiener Indices, along with higher infauna percentages as compared with Holocene (non-seep) sediments. These isotope and assemblage characteristics of foramimifera may be results of the attenuation of cold-seep activity since LGM.

Key words: sedimentary geochemistry, benthic foraminifera, methane seep, South China Sea