Core observations of a cold-seep assemblage in the lower Pleistocene forearc basin fill at Segami, Pacific side of central Japan

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A cold-seep assemblage occurs in a slope to outer shelf facies of the Plio-Pleistocene Kazusa Group, a forearc basin fill deposit, exposed at Segami, northern part of the Miura Peninsula, Pacific side of central Japan. The following observations has been documented previously in Tate and Majima (1998) and Kitazaki and Majima (2003) based on exposure and bore-core (cores A-C) survey. This cold-seep assemblage mostly consists mostly of large size, attaining to 10cm in maximum diameter, and articulate bivalves of *Lucinoma*, *Conchocele* and *Acharax* in aggregate or sporadic occurrences. In bedding normal length, the distribution of the assemblage attains to at least 37m across the formation boundary between the Koshiba Formation above and the Ofuna Formation below. In bedding-parallel length, it distributes at least 16m in the north-south direction and 30m in the east-west direction. The assemblage often accompanies with authigenic carbonate concretions, which develop in the study area in various density and are depleted greatly in ^{13}C ($d^{13}C$ = -47.99 to -55.06 per mill). Two observations, an extremely abundant occurrence of broken bivalve, some of which are fragmented into very small pieces, and lithologic boundaries conflicting greatly with the general trend of dipping in the study area suggest to be a result of severely activated seepage and/or explosive effusion of subsurface fluid or gaseous materials. These results evidently indicate that the assemblage was depended on a methane seepage.

We recovered the additional four cores (core D 15m in depth, core E 108m, core K 30m, and core L 30m in depth) to describe the detailed relationship between lithology and the cold-seep assemblage, to date the cores by analyses of foraminiferal isotopes and calcareous nannofossils, to measure the carbon and oxygen stable isotope ratio of the authigenic carbonates, and to measure concentrations and carbon isotope ratio of some lipid biomarkers originated from archaea and bacteria, which are dominated in the zone of anaerobic methane oxidation (AOM). In core E, the longest core, the following observations are obtained.

1) Six seep stages 1-6, from bottom to top, are recognized based on the bedding normal distributions of large bivalves and developments of authigenic carbonates, aragonite, HMG-calcite, and dolomite: Stage 1 is recognized in the depths below 108m; Stage 2 in 59-7m; Stage 3 in 21-34m; Stage 4 in 16-21m; Stage 5 in 6-14m; and Stage 6 in 0-4m.

2) Depth changes in $d^{13}C$ values of authigenic carbonates during Stages 2 and 5 show very similar pattern to the vertical d13C profiles of interstitial water DIC (dissolved inorganic carbon) of modern seep sites. These finding offers us to reconstruct the level of horizons of sea bottom and AOM in the core, when authigenic carbonates were recipitated. The sea bottom and AOM are estimated to be at levels of 6m and 7-9m (Stage 5), and 59m and 61-63m (Stage 2), respectively, based on the upper-limited occurrence of articulate large bivalves for sea bottom and the AOM zone characterized by the horizons of the lowest $d^{13}C$ values in the authigenic carbonates.

3) In the core depths of 7-9 (Stage 5) and 60-62 m (Stage 2), we observed elevated concentrations of lipid biomakers characteristic for archaea including PMI, crocetane, and biphytanes with extremely low $d^{13}C$ values (commonly lower than -120 per mill). They strongly suggested that the AOM use to occur actively in these intervals.

4) Based on the age model of the core by calcareous nannofossil stratigraphy and $d^{18}O$ profile of *Globorotalia inflata*, the seepage might have continued to be active at least for 210 ka and were probably activated in warming periods at MIS 59-60 (60-101m, Stage 2) and MIS 58-57 (20-36m, Stage 3) at least, where large bivalves occur abundantly and authigenic carbonates developed distinctly.