A cold-seep assemblage associated with authigenic carbonate, Takanabe Formation, Miyazaki Group, Japan

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A cold-seep assemblage consisting of the large bivalve (*Lucinoma* sp.) is exposed at the Kuge Shrine, Koyu Country, Miyazaki Prefecture, Kyushu Island, Japan (Majima et al., 2003). This assemblage occurs in upper part of the Takanabe Formation of the Miyazaki Group with a general dip about 10 degree E and a general strike about N10 degree E at around the Kuge Shrine and is associated with authigenic carbonate depleted greatly in ^{13}C ($d^{13}C$ = -30.69 per mill to -53.21 per mill vs. PDB), which suggests the influence of methane seepage (Majima et al., 2003).

Two bore-cores were studied. A 75m-long core No. 1 was drilled perpendicularly to the bedding plane at the shrine, and is used to describe stratigraphic distributions of the bivalves, authigenic carbonate and characteristics of authigenic carbonate. A 80m-long core No.2 was drilled normal to horizon in a non-seep site, about 700m northeast of the the Shrine and is mainly studied for the chronology to determine when the methane seepage has occurred, based on the magnetostratigraphy, calcareous nannofossil biostratigraphy, and stable isotope analysis of planktic foraminifera. From these analysis, we are trying to describe clearly the methane seepage events in relation to the global climate change.

Two cores are well-correlated with three tuff beds: UTT-1 (found at 70m core-depth in core No. 1, and 71m core-depth in core No. 2, respectively), UTT-2 (62m in No. 1, 60m in No. 2), and UTT-3 (24m in No. 1, 32m in No. 2). The UTT-3 is thought to be equivalent of the NGT-1 tuff bed of Torii et al. (2000), who dated it at 2.71Ma. The cores clearly show a sequence of upward-coarsening sediments followed by upward-fining sediments, of which lithologies are the followings: irregular alternation of mudstone and sandstone, sandy mudstone, muddy sandstone, and sandy mudstone and mudstone in ascending order.

Analysis of Core No. 1 has revealed as follows. 1) The large bivalves repeatedly occur in 12 horizons of 71-74m, 53-54m, 42-48m, 34-40m, 29-31m, 25-28m, 22-24m, 20-21m, 16-19m, 12-15m, 9-11m, 3-6m, and thus it suggests strongly that methane seeped repeatedly. Below 29m depth, these distibution patterns mostly correspond to those of sandy mudstone, but not to background sediments of mudstone. 2) Authigenic carbonate seen above 22m core-depth occurs together with large bivalves, while those seen below 22m depth occurs without relation to the distribution of large bivalves. 3) Authigenic carbonate minerals are composed of aragonite, low-Mg-calcite, high-Mg-calcite, and dolomite. 4) The $d^{13}C$ of high-Mg-calcite of authigenic carbonate ranges from -54.2 per mill to -51.3 per mill vs. PDB, and the $d^{13}C$ of dolomite ranges from -51.1 per mill to -30.8 per mill vs. PDB. The $d^{18}O$ of high-Mg-calcite of authigenic carbonate ranges from 1.7 per mill to 2.8 per mill vs. PDB, and the $d^{18}O$ of dolomite ranges from 1.9 per mill to 3.8 per mill vs. PDB. 5) The vertical profile of $d^{13}C$ of the authigenic carbonate in 34-40m depths resembles vertical subsurface profiles of $d^{13}C$ of dissolved inorganic carbon at modern cold seep sites.

As a results of Core No. 2 analysis, the upper part of the Takanabe Formation assign to the Upper Pliocene. This result was estimated for the following reasons: 1) The NGT-1 tuff bed (2.71Ma) is intercalated in cores, and the TNP-1 and HUT-1 tuff beds of Torii et al. (2000) were dated at 2.79Ma and 2.17Ma, and are intercalated below and above core horizons, respectively. 2) Polarity is changed in the depth interval between 10m (reversed polarity) and 17m (normal polarity) in depth. This paleomagnetic reversal is inferred to be the Matuyama/Gauss boundary based on calcareous nannofossil biostratigraphy.