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# Habitat of fossil bathymodiolins from methane-seep limestone in the Miocene Bessho Formation, central Japan

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Bathymodiolin mussels are one of the dominant bivalves in chemosynthetic communities in Recent vent and seep environments. In spite of their common occurrences on the present deep-sea bottom, their fossil records are rare compared with other chemosynthetic bivalves such as vesicomyids and lucinids, and few paleoecological studies have been examined. The lower Middle Miocene Bessho Formation, slope muddy facies of an intra-arc basin, northern Fossa Magna, contains large methane-seep carbonate blocks (the Akanuda and Anazawa Limestones), over 20 m in diameter, which yields abundant bathymodiolin fossils (Bathymodiolus(s.l.) akanudaensis) as well as vesicomyid Adulomya uchimuraensis. This study reports the detail mode of fossil occurrence with carbonate petrology and sediment fabrics, and reconstructs the habitat condition of fossil bathymodiolin shells from taphonomical viewpoints.

The bathymodiolin fossils occurs not only sporadically in the Adulomya-dominant muddy micrite, but also form dense and exclusive shell-clusters, about 50 X 50 cm area, over 30 cm depth. It is noted that almost all of bathymodiolin fossils are small-sized conjoined valves, in contrast to vesicomyids, most of which are large and frequently disarticulated. The maximun shell length is over 55 mm, but the mode of shell length ranges 10-15 mm. The high ratio of conjoined valve (87 %) and the age structure biased toward juvenile stages suggest that the almost all of bathymodiolin mussels were rapidly buried on the way to full-growth.

The bathymodiolin shell aggregation is included in muddy micrite facies close to the strongly hydro-fracturing facies, which consists of micrite breccias and calcitic veinlets. Polished slab samples of the bathymodiolin-rich micrite indicate that 1) the bathymodiolin shells are supported by muddy matrix partly showing hydro-fracturing texture; 2) there is no rock clusters providing hard substratum for bathymodiolins to attach; and 3) red-brown semi-consolidated mud clasts were mixtured into the hydro-fracturing matrix. The red-brown mud were maybe originally bottom-surface sediments where bathymodiolins lived in because the red-brown mud fill the inside of conjoined valves.

We examine shell-orientations for 107 individuals in a block sample, ca 10 X 10 X 20 cm. The bathymodiolin shells not only scatter in the matrix, but also form small clusters. The following trends are recognized regardless of shell size and whether the shells are scatter or form a cluster: 1) About 60% of the population show their commissure planes inclined over 30 degrees; and 2) most of the individuals are in roll-over positions but some are in erect or inverse-erect positions in which the shell long axis is nearly vertical. Trend of shell long-axis arrangement cannot be recognized for all specimens but an orthogonal set of two directions is recognized for roll-over shells. The buried condition coexisting roll-over, erect, and inverse-erect shells may be due to reworking caused by shear strength in mud-flow medium. The orthogonal set of two directions for roll-over shells maybe corresponds to a set of rolling position of cylindrical shell form and minimum-resistance position against the flow.

The mid-Miocene bathmodiolin mussels maybe depended on active seepage flow, which was associated with subsurface hydro-fracturing and brecciation. Such a high seepage activity frequently caused local mud flow and/or mass-sliding, resulting in rapid burial of bathymodiolin populations.

Keywords: chemosynthesis, Bathymodiolus, methane-seep, Bessho Foramtion