

## Case studies on subbottom reconstruction of fossil seep-sites: For comparative works with submarine mud volcanoes

\*Takami Nobuhara<sup>1</sup>

1. Science Education (Geology), Faculty of Education, Shizuoka University

Outcrops of fossil seep sites provide us chances to directly observe subbottom lithology and texture, which recorded seepage conduits and their temporal change under the interaction with early diagenesis and seep activity. Such high-resolution images on seep activities based on land sections can complement geophysical marine subbottom profiling, which leads to total-understanding for seep-related phenomena. This review work shows some case studies on subbottom reconstruction of fossil seep sites by detail mapping of litho- and biofacies at the outcrop scale. Their paleo-seep activities have not yet been proved to be directly caused by mud volcanoes, but are worth for reexamination on its relation.

One of the representative cases is the Upper Miocene Bessho Formation, Nagano Prefecture, central Honshu. The Bessho Formation consists of slope-facies siltstone and intercalates a various-sized seep carbonates, ranging from less than 1 m to over 20 m in diameters. They are irregular-shaped, arranged in mosaic pattern and intermittently accumulated over 30 m in vertical section. The seep-carbonate consists of fractured muddy micrite with calcitic veins, fringed by fibrous aragonite and calcitic blocky spar. The lithology is characterized by two types of fluidizing texture: 1) autobrecciated micrite supported by microsparitic matrix (subbottom fracture by high pore-water pressure); 2) chaotic mixture of hard micrite breccia and semi-consolidated calcareous silt lumps, supported by muddy matrix (muddy debris associated with erupting focused flow). It is noteworthy that the former lithofacies are sometimes isolated in the siltstone matrix, and not recognized to be connected to other fractured parts. The seep activity was intermittent, and repeated the two phases between focused eruption and concretion sealing. In such sites, seepage activity was heterogeneous in time and space, from focused to diffusive, which resulted in mosaic distribution of fossil vesicomyid and bathymodiolin communities and high-species diversity of chemosynthetic animals.

Another representative case is the Upper Miocene Morai Formation, Hokkaido, North Japan. The Morai Formation consists of alternating beds of hard and semi-consolidated siltstones, which deposited on the upper slope of the back-arc Japan Sea. The Morai Formation intercalates lens-shaped dolomitic carbonates, several meters in length, which abundantly yield vesicomyid fossils in autochthonous mode of fossil occurrence. The vesicomyid shell beds are traceable over 20 m along the bedding, crossing over the carbonate/siltstone boundary. In contrast with the case of the Bessho Formation, the Morai seep carbonates consists of monotonous dolomicrite and lacking a fluidizing structures with aragonite and calcite cements, which suggests that the seep activity was not focused but diffusive. Moreover, we cannot recognize any effective seep conduits such as faults and pipe structure on the outcrop. The influence of diffusive seep was homogeneous and wide-spread, which led to monotonous fossil assemblages dominated by vesicomyids. It is not clear how methane was supplied to subsurface depth of the vesicomyid habitats thorough compacted siltstone over 20 m thick, but it is worth to examine the influence of lateral mass flow of methane-rich mud.

Keywords: fossil cold-seep site, Cenozoic, chemosynthetic community