

An offshore mud volcano that indicates a heterogeneous subseafloor geological environment: a case study along southwest Japan

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Mud volcanoes (MVs) are geological features that derive fluids and sediments from the depth to surface. Offshore MVs require continuous mud emission to maintain the shape on the seafloor against erosion (Kopf, 2002). Brown and Orange (1993) mentioned that gas is required for sediments moving up from the deep. These necessary conditions for the existence of mud volcanoes restrict the subseafloor environment beneath MV fields.

In Japan, MVs are found both on land and in offshore areas (e.g., Tajika et al., 2009; Kuramoto et al., 2001). A forearc basin, the Kumano Basin, which is bordered by the Nankai Trough along its southern edge, is a representative MV field in Japan. There are at least 14 MVs in the basin (Kuramoto et al., 2001; Morita et al., 2004; Pape et al., 2014; Asada et al., 2017). The recent morphological changes in an MV and the emission of gas bubbles from the top of the MV were discovered through acoustic investigations in the Kumano Basin in 2016 (Menapase et al., 2017), which implies that these MVs actively emit fluid and sediment on the seafloor. Additionally, a group of offshore MVs is known in the off-Tanegashima area in the southeastern part of the Kyusyu Island (Kitada et al., 2018). There are at least 14 MVs, and life moved from the MV to the seawater (Hoshino et al., 2017). Moreover, several MVs have been reported in the off-Miyazaki area of the eastern Kyusyu Island. The Hyuga-nada area, a northeastern part of the Kyusyu Island, probably holds other MVs that exhibit similar bathymetric and acoustic (backscatter) characteristics as MVs in the Kumano Basin and the off-Tanegashima areas. Only one MV candidate feature and the hardened seafloor around it have been recognized in the off-Shikoku Island; however, there are no more MVs in the area. These results indicate that there are discontinuous MV fields along southwest Japan, and there is a vast MV field over the eastern offshore area of Kyusyu Island. This indicates a heterogeneous subseafloor environment in these areas.

Within what type of subseafloor environment can MVs exist? Maintaining a continuous emission of fluid and sediment on the seafloor may restrict the subseafloor environment.

1. A budget of “fluidized mud” or continuous production of “fluidized mud” should exist under the seafloor.
 - Large amounts of seawater are trapped when deposits are buried without being drained.
 - Dehydration owing to clay minerals collapses the mud rock to form fluidized mud.
 - Gathering fluids come along the strata and/or fault to collapse mud rock and make fluidized mud.
2. Gas is required for making intrusions, which can be a root of MVs.
 - Sediment can yield enough thermogenic and/or biogenic gas.
 - There is an environment for collecting enough fluid coming through the strata and/or fault.
3. Both gas and fluidized mud under the seafloor can be the origin of MVs on the seafloor. Only one of them may not lead to MVs.

The subseafloor temperature of the accretionary prism of the Kumano Basin (e.g., Marcaillow et al., 2012) satisfies the condition for the dehydration of clay minerals. The dehydration may cause the collapse of mud rock, yielding fluidized mud. Gas generation causes sediment intrusion. This fluid may flow along the strata and fault and gather together to cause MVs. As with Hyuga-nada/off-Tanegashima area, there is a

business gas field along the eastern coast of Kyusyu Island, and it may affect the area. However, in the off-Shikoku area, there is not enough subseafloor environment to generate gas and fluidized mud; this may be affected by the high-temperature subduction of the ancient plate-spreading axis in the Shikoku Basin. This subseafloor heterogeneity may be related to other geological phenomena, such as the patchy distribution of the seismogenic zone.

Keywords: Mud Volcano, offshore area along SW Japan, subseafloor environment