Shallow marine mud volcanoes in the Miocene Tanabe group, Kii Peninsula

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The component material and intrusive structures of several mud diapirs in the Miocene Tanabe Group, southwest of the Kii peninsula were examined to reveal the fluid intrusion style and processes. To examine factors controlling the intrusive styles, tank experiments were also performed. Three types of intrusive structures such as cylinder, dome, and sill types were observed in ascending order in the Shirahama Formation overlying the muddy Asso Formation of the Tanabe Group. (1) Cylinder type: The Ichieminami mud diapir, the about 20m in diameter, intruded into bedded sand and siltstones almost vertically. The majority matrix is siltstone, with subordinate sand and quartzose sand in inner part. (2) Dome type: Ichiezaki mud diapir has a dome shape of about 150m in diameter including blocks and sand grains of host sediments by stoping. Many mud dykes radially intruding into hostrocks are clayey in the early stage and sandy in the later stage. (3) Sill type: The mud diapir of the Migusa represents the lens shaped lacolith with at least 200m in diameter, mainly consists of pebbly mudstone involving blocks of surrounding strata. There are small-scale mudstone sills and dykes around the diapir. As a result of tank experiments, it was observed that a series of lenticular intrusive slurry body with dome like upheaval, transforming into the mud chamber expanded involving blocks and particles of the host sediments. As it collapsed, a conduit of upward escaping muddy fluids, sill and dyke structures are formed above the chamber. Based on the correlation between the diapiric structures in the Tanabe Group and intrusive features in the tank, (1) Cylinder type intrusion is indicative of conduit of the fluid to the chamber. Such a vertical path shows a concentrated fluid flow cut through permeable sedimentary strata without any muddy impermeable intercalation. (2) Dome type diapir corresponds to a mud chamber or the upper most part of a cylinder type intrusive body where the stoping process is most predominant. (3) Sill type intrusive body is thought to represent the mud chamber intruded into layered sedimentary sequence with remarkable permeability contrast. These diapirs of the Tanabe Group show a variety of intrusion by a single event that a high-pressured fluid with small amount of mud injected through a narrow conduit to the level where a large mud chamber expands one after another, by which different types of intrusive structures are formed in accordance with permeability contrast and the degree of solidification of the host sediments. Subaqueous debris flow depsits erupted from a mud volcano (Nakaya and Hamada, 2009) more than 100m in thickness have been reported from middle to upper member of the Shirahama Formation. Small scale (less than 20m) fluid intrusion structures were also found in several horizons of the upper member of the Shirahama Formation. At least, some of those structures display characteristic deformation style suggesting the fluid as gas phase. Carbonate nodules and chimneys were found in from the uppermost Asso Formation. The carbon stable isotope ratios of calcite and dolomite in nodules and chimneys ranges from -22 to 7 permil. (PDB), and the oxygen stable isotope ratios ranges from -20 to 0 permil. (PDB). Pyrite nodules less than 10 cm in diameter are formed in the fluid intrusion structures in several horizons of the upper member of the Shirahama Formation. The sulfur stable isotope ratios of the pyrite nodules are ranging from -4.3 to +l.4 permil. (CDT), which are similar of those in carbonate nodules and chimneys. Thermal or deep-seated fluid with CH4/CO2/H2S gases might have been erupted to the shallow water area at the time of regression stage of the Tanabe Group.

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