

# Formation and the origin of the Kumano mud volcanoes

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Detailed topographic surveys and submersible investigations have identified seven mud volcanoes so far on the Kumano Basin floor. The mud volcanoes are situated above seismogenic zone of the Tonankai earthquake, and origin and the source of the mud diapirism which generates in the area of the earthquake in a cycle of around one hundred years should be traced. Our purpose is to clarify processes of formation of the mud volcanoes in the Kumano Basin by performing structural analyses and geological investigations. We mainly used METI's seismic data for the structural analyses, and observation records and subbottom materials obtained by submersible dives with SHINKAI 6500 (YK02-02) and ROV KAIKO (KR02-10 and KR03-05) were applied to offer a geologic constraint.

The Kumano Basin is the largest forearc basin in Nankai accretionary prism. The present feature of the basin shows a flat seafloor through the whole area at generally 2,000 m in depth. The seismic data analyses found that deep geologic structure of the Kumano Basin can be divided into two portions, the north and the south zones. The north zone of the Kumano Basin has three anticlines with 5-10 km intervals. However, the south zone indicates a large extended sedimentary basin dammed up by uplifted outer arc high, excepting two anticlines in the east end of the south zone. Their uplifts seem younger to the south, because the sedimentary basins between the anticlines indicate basically north dipping. The Kumano mud volcanoes are well related to the geologic structure of the Kumano Basin. They are all situated above the anticlines latent below the flat seafloor, so the mud volcanoes appear in the north zone and in the east end of the south zone of the Kumano Basin.

The mud volcanoes are generally around 100 m high and less than 2 km in diameter. Rubbly clastic ejecta from the mud volcanoes are composed of semi-consolidated mudstone, mud breccia and biotite-rich arkose sandstone (bt-qtz arenite). Identified nannofossil indicates that most of the rubbles are sedimentary rocks originally deposited in the late Early Miocene through the Middle Miocene. This age corresponds to old abandoned forearc basins on Shimanto accretionary belt in Kii Peninsula, i.e. Kumano Group and Tanabe Group. The Kumano Group is composed of biotite-rich acidic rocks and related sedimentary rocks, and the Tanabe Group is known for clastic dikes and mud diapirism which can be observed on outcrops. These features suggest that the formation of the Kumano Basin was initiated in or by the late Early Miocene, concurrently with formations of the neighbor abandoned forearc basins on Shimanto accretionary prism. Since then, the Kumano Basin has developed until today, suffering deformation accompanying development of Nankai prism. Accordingly, the deformation has formed the anticlines and has led to diapirism to create the Kumano mud volcanoes.

As a result of pyrolysis by Rock-Eval method, analyzed clastic ejecta of the mud volcanoes, the mudstone and the mud breccia, are all immature for natural gas generation. Nevertheless, hydrocarbon gas extracted from pore water in subbottom sediments of the mud volcanoes have been previously reported as thermogenic origin. Taking account of these results, it is necessary to consider origins of the lithics and the pore fluid of the mud volcanoes separately.