Geological and seismic approaches to Kumano mud volcanos in the eastern Nankai accretionary prism

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Kumano Basin is a forearc basin on the eastern Nankai Accretionary Prism off southwest Japan. Recent bathymetric survey showed existence of small knolls in the Kumano Basin. Submersible and ROV dives, sidescan sonar and deep-towed camera investigations revealed so far that at least five of the small knolls are mud volcanoes erupted on the Kumano Basin floor.

Multi-channel seismic exploration data, which was acquired by Japan National Oil Cooporation in 2001, shows clear cross-sectional images of some of the mud volcanoes in the Kumano Basin, for example Kumano Knoll No.3. Seismic velocity analysis helped to examine more detailed geometry and physical properties of the mud volcanoes.

In June and August, 2002, Dive 677 and 681 by submersible SHINKAI 6500 (YK02-02: R/V Yokosuka) and Dive 267 by ROV KAIKO (KR02-10: R/V Kairei) were performed in one of the mud volcanoes, Kumano Knoll No.4, which is 100 m high and 800 m in diameter at the foot of the knoll. The knoll has a plateau of about 300 m diameter on the top, which shows bumpy surface where there are waves, steps and craters of several meters in diameter. The craters imply active or dead cold seeps and are occasionally accompanied by Calyptogena colonies. The plateau is mostly covered with mud. Rock gravels and boulders were observed mainly on outer slope of the knoll. Sidescan sonar and subbottom profiler data by KAIKO system show marked contrasts in sonic reflectivity and penetration between the Kumano Knoll No.4 and the Kumano Basin floor. The high sonic reflectivity and the low penetration on the knoll indicate that main body of the knoll is composed of clastic ejecta as a mud volcano.

On the Kumano Knoll No.4, the dives obtained semi-consolidated mudstone, mud breccia, and biotite-rich arkose sandstone (Bt-Qtz arenite). Chronological analysis on nannofossil indicates the sedimentary rocks are in the late Early Miocene through the Middle Miocene. According to this age and geological information on land, it is likely that the sedimentary rocks on the knoll were originally deposited at the beginning of formation of the Kumano Basin because Kumano Formation in kii Peninsula, which is an old forearc basin on Shimanto accretionary prism, on the west of the Kumano Basin indicates the same age and is composed of the similar sediments. Porosity of these sedimentary rocks is very low (less than 18 %). Some mud breccias contain calcite veins that cut the angular mud gravels.

Judging from pore water in sediments on Kumano mud volcanos, hydrocarbon gas composition and carbon isotope of methane indicate that the gas contains thermogenic origin. However, maturity measurements by Rock Eval method indicate low T-max (420-439 degrees centigrade) for the mud volcano rocks. This means the rocks are immature yet as hydrocarbon gas source. Thus, it can be considered that the ejecta sediments and the fluid extracted on the mud volcanoes have been derived from different depth of the Kumano Basin or an old accreted portion of the Nankai accretionary prism below the basin.

Further seismic analyses, rock analyses and other geological investigations will clarify histories of formation of the Kumano Basin and the Kumano mud volcanoes.