The Ascension Process of the Fluid from the Mud Volcanoes along Anticline and Fault Zones

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We conducted geological surveys and geochemical analyses of the groundwater and the gas expelled from the mud volcanoes along the Chishan Fault (CMV) and along the Gutingkeng Anticline axis (KMV) in the southwest Taiwan to generalize the ascending process of highly saline groundwater erupted from the mud volcano. Also, we performed the geophysical exploration of the CSAMT method around the Wushanding mud volcano along the Chishan Fault.
Yanchao area in the southwest Taiwan is composed of Miocene Gutingkeng Mudstone, Wushan Sandstone and Pliocene Erchuangchi Shale. In addition, the reverse faults with NE-SW trend and SE dip (the Chishan Fault) and an anticline with NNW-SSE trending axis are distributed in the Yanchao area. Furthermore, we classified the mud volcanoes in the southwest Taiwan into 4 types based on the morphological feature. The Corn type is characterized by a conical high mound with the height of more than 1 m. The Pudding type is also characterized by a conical high mound with the height less than 1 m. The Crater type is characterized by an inside wall. The Pool type is characterized by a pool and without a mound. The Cone type is only observed in CMV. Along a fault, it is assumed that the fluid from the mud volcanoes with low water content ascends along the fault zone containing much clay like a fault gouge. The $\delta^{18}O$ of CMV is heavier than those of KMV. It is assumed that the $\delta^{18}O$ of groundwater from the mud volcano along a fault zone become heavy due to the water-rock interaction happened in deep underground. Gases of CMV are thermogenic. Those of KMV are characterized by the mixing of thermogenic one and microbial one. It is thought that the microbial gas is generated near the ground surface and mixed with the ascending thermogenic gas. Moreover, the erupted gases from the mud volcano distributed in the southwest Taiwan are biodegraded. The degree of biodegradation differs in each mud volcano in CMV. In contrast, the variation of biodegradation is small in the mud volcanoes in KMV. In addition, the maximum burial depth of the vitrinite of CMV is estimated to be about 3,500 m deep that is deeper than that of KMV (2,500 m) by the relationship between the vitrinite reflectance and geothermal temperature. Low electric resistivity zone obtained by the CSAMT exploration corresponds to the distribution of the Chishan Faults in the Yanchao area. Therefore, it is concluded that the fluid ascends through the Chishan Fault zone.
Based on the results obtained in the study and previous studies, we supposed the ascending process of the erupted fluid from the mud volcano as follows. At first, abnormal water pressure is formed in deeper at the fault zone than that at the anticline. The fluid from deep underground stay in the mud chamber once located shallow underground under the mud volcano along an anticline axis. Then, the fluid ascends with making cracks by the high gas pressure caused by de-gassing. Then, the fluid is erupted violently to the ground surface and forms the mud volcano with forming the morphological depression. On the other hand, the fluid ascends through the fault zone consisting clayey fault gouge under the mud volcano along the fault zone. The fluid involves clay and mud when it ascends through the fault zone. Then, the fluid ascends through various paths in the fault zone. Finally, most of the fluids erupt to the ground surface gently and form the Cone type mud volcano.

Keywords: mud volcano, Taiwan, fluid, anticline, fault zone, CSAMT method

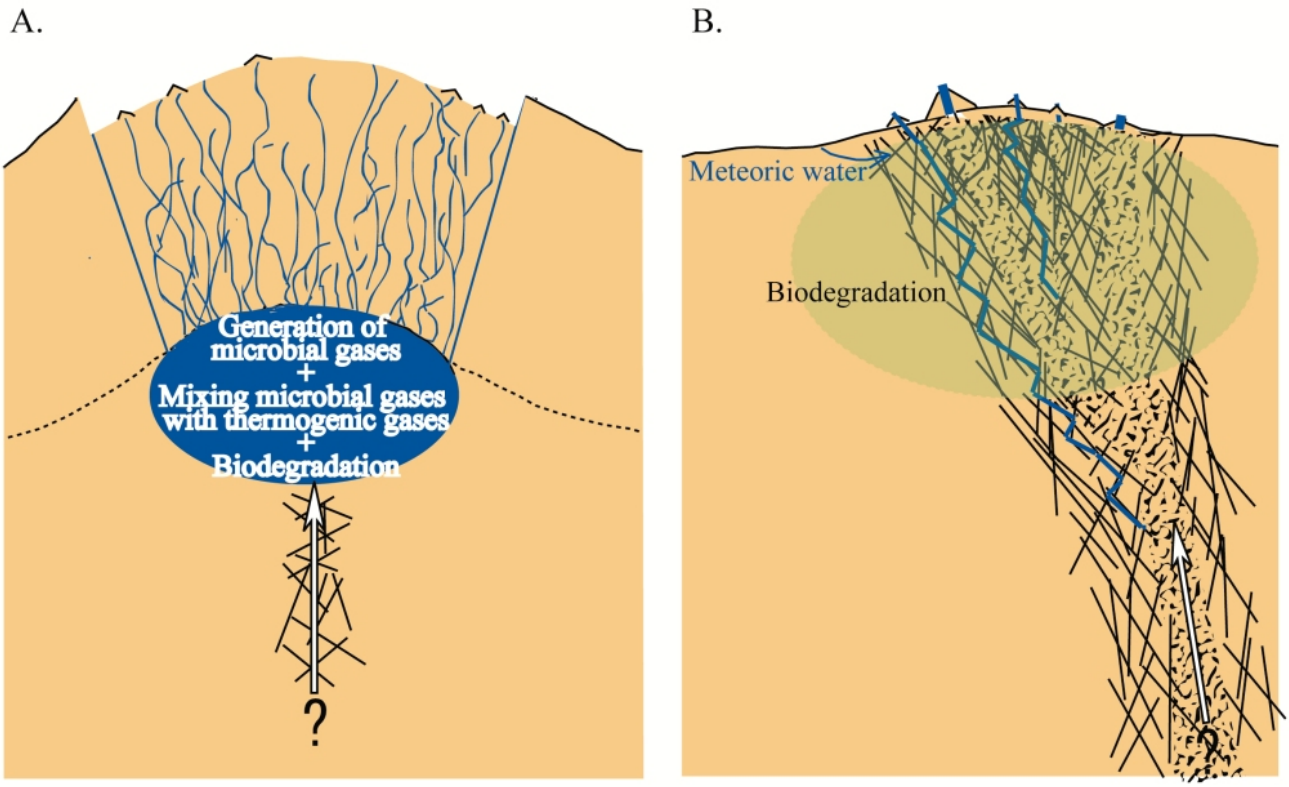

Fig. 1. The ascending model of the fluid erupted from the mud volcano in shallow underground. A: Anticline axis, B: Fault zone

