Constraints on origin of mud-volcano sediments from clay mineral compositions in submarine mud volcanoes in the Kumano forearc basin, Nankai Trough

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Submarine mud volcanoes are remarkable seafloor features that consist of mud breccia derived from sediment layers beneath the seafloor. They form by expulsions of mud and associated warm, deep-sourced fluids, predominantly methane gas. The origin and composition of these fluids have been the subjects of many studies. These studies have shown that the fluids commonly originate from dehydration reactions of clay minerals. The fluids also contain hydrocarbon gases derived from thermocatalytic decomposition of organic matter. These characteristics suggest that the fluids originate at depths where temperatures are high enough to promote these reactions. However, the lithological studies including the analysis of chemical and mineralogical compositions of the mud-volcano sediments are fewer than the studies on fluids, although the lithology of erupted sediment is strongly related to the formation of mud volcanoes and the source of their sediments. Given the large proportion of clay in submarine mud volcanoes, clay mineralogy is an important characteristic of mud-volcano sediments, particularly signs of clay mineral dehydration that is an important proxy for thermal history of sediments. In this context, we determined the clay mineral compositions of sediment from submarine mud volcanoes in the Kumano forearc basin, Nankai Trough, by X-ray diffraction analysis. The compositions were dominated by smectite (average 49%). Similar compositions in other mud volcanoes in the Kumano basin indicate that the mud volcanoes in the basin are rooted in the same source sequence. These clay mineral compositions differed from those in Pleistocene basin sediment at Integrated Ocean Drilling Program Site C0002, in the southern part of the Kumano basin, suggesting that the mud-volcano sediment originated beneath the Pleistocene sediment. The illite content in the illite-smectite mixed layer averaged 32% in the mud-volcano sediment, which implies that the sediment experienced temperatures above 60˚C that promoted the smectite-to-illite transformation. However, porewater extracted from the mud-volcano sediment had Cl^- concentrations roughly half that of seawater and proportional enrichment in ^{18}O and depletion in D in porewater, indicating that dehydration reactions of clay minerals had previously occurred in a deeply buried sedimentary layer. The smectite and illite contents (<60%) in the clay-size fraction rule out in situ smectite dewatering as the cause of the dilution of Cl^- in porewater. Thus, fluids derived from clay dewatering must have originated from deeper than the source of the mud-volcano sediment.

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