Evidence for low temperature smectite to illite transformation in the Bering Sea slope sediments (IODP Expedition 323)

*Akira Ijiri[1,2], Naotaka Tomioka[1], Harue Masuda[3], Shigeyuki Wakaki[1], Masafumi MURAYAMA[4], Fumio Inagaki[1,2]

1.Kochi Institute for Core Sample Research, Japan Agency for Marine Science and Technology (JAMSTEC) , 2.Research and Development Center for Submarine Resources, JAMSTEC, 3.Graduate School of Science, Osaka City University, 4.Kochi university, Center for Advanced Marine Core Research

The smectite to illite (S-I) transformation is a kinetically or thermodynamically controlled diagenetic process with dehydration in sediments at a relatively high temperature range of 60℃ to 150℃. The S-I transformation also significantly impacts on *in-situ* physical and geochemical characteristics, such as pore water pressure, faulting, and migration of hydrocarbon gasses. Recent experimental studies showed that anaerobic iron-reducing microbial activity of possibly promoted the S-I transformation at low temperatures (Kim et al., 2004). However, the low temperature S-I transformation has not been observed in natural sedimentary environments. In this study, we demonstrate here the transformation of S-I at <40C in the Bering Sea Slope sediments based on the pore water chemistry, clay mineral composition, and microstructures. The sediment samples were obtained by drilling down to ~800 m below seafloor (mbsf) at Sites U1341 (Bowers Ridge), U1343 (Bering Sea Slope) and U1344 (Bering Sea Slope) during the Integrated Ocean Drilling Program (IODP) Expedition 323.

Geochemical analyses of pore water samples from Bering Sea Slope sediments showed that chloride concentrations slightly decreased from ~550 mM near the seafloor to ~500 mM at the core bottom. Dissolved potassium concentrations decreased from ~13 mM at 150 mbsf to 6 mM at the core bottom. Below 150 mbsf, oxygen and hydrogen isotopic compositions of pore water (H_2O) increased from 0‰ to 1.5‰ and decreased from -2‰ to -10‰ with increasing depth, respectively. These trends would be attributed to the release of dehydrated water into the pore water and the potassium uptake by the authigenic S-I transformation. However, those trends were not observed in sediments from the Bowers Ridge. The Illite/smectite mixed layered clay minerals, which are the intermediate products of the S-I transformation, were identified only from the Bering Sea Slope sediments based on XRD analyses of the clay-sized fractions. Illite content of the Illite/smectite mixed layered clay minerals increased from 2% near the seafloor to ~8% at 200 mbsf. TEM lattice fringe image of the clay minerals in 210 m-deep sample at Site U1343 showed that the layers of 1.0-nm spacing, which were illite, partially distributed at the tip of hairy shaped authigenic smectite particles, clearly indicating the occurrence of S-I transformation *in situ*. Because the thermal gradients at Sites U1343 and U1344 were 49.0℃/km and 53.3℃/km, respectively, indicating that the temperature ranged in the cored sediments was generally lower than 40C. Consequently, our geochemical, geophysical and mineralogical data indicate that the low temperate S-I transformation occurs below 150 mbsf in the Bering Sea slope sediments. A possible explanation for this phenomenon is the contribution of microbial activity such as iron reduction. Interestingly, the occurrence of authigenic siderite ($FeCO_3$) concretion was observed only below 150 mbsf at the Bering Sea Slope sediment (Pierre et al. 2014), supporting the increase of alkalinity by microbial decomposition of organic matters and reduction of Fe (III) to siderite that leads to the low temperature S-I transformation.

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