Clay Mineral Provenance and Clay Diagenesis Deep in the Nankai Accretionary Prism: Results from IODP Riser Drilling, Nankai Trough Seismogenic Zone Experiment

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IODP Expedition 348 set a new record for sampling depth by scientific ocean drilling. Cores were recovered from the Nankai accretionary prism (Site C0002) at depths of 2163-2218 mbsf; cuttings were recovered continuously to 3058 mbsf. Shallower strata near the top of the accretionary prism are as young as 5.6 Ma, but the deeper intervals have an apparent depositional age of 9.56-10.73 Ma. The steeply dipping Miocene strata lie within the hanging wall of the subduction megathrust and are buried beneath Quaternary turbidites of the Kumano Basin. Quantitative analyses of the clay mineral assemblages (using X-ray diffraction) show that the most abundant clay mineral is smectite, followed by illite, chlorite, and kaolinite. The accreted mudstones at Site C0002, however, contain significantly lower percentages of smectite (<25% of the bulk mudstone) as compared to coeval Miocene strata at Sites C0011 and C0012 (Shikoku Basin); those present-day subduction inputs generally contain >40% smectite in the bulk mudstone. One likely reason for the compositional difference is an overprint of the detrital assemblages by smectite-to-illite diagenesis; that reaction results in a steady down-hole increase in illite within the I/S mixed-layer phase. The extent of I/S reaction progress is consistent with kinetic models in which the peak heating time is limited to about 1 Myr, as might be expected with rapid Quaternary accumulation of sediment within the overlying Kumano Basin. Another possible reason for lower contents of smectite, however, is a spatial shift in the depositional environments and detrital provenance of subduction inputs during the Miocene. The mud-dominant facies of the older accretionary prism is enigmatic (when compared to the frontal prism), and its original depositional setting remains uncertain. The older accreted mudstones might have been deposited in a trench during a time period in which supplies of sandy sediment were restricted. An alternative explanation involves northeastward migration of the triple junction that joins the Japan, Izu-Bonin, and Nankai plate boundaries. The depositional settings prior to accretion may have shifted over time from the NE side of the triple junction (subducting Pacific plate) to the SW side (Shikoku Basin, subducting Philippine Sea plate). Regardless of exactly how and when the paleogeography evolved, smaller initial percentages of detrital smectite, combined with the gradual diagenetic loss of smectite with depth, are important for predicting how material properties change toward the seismogenic plate interface. We should see progressive reductions in the volumetric contribution of pore fluid from I/S dehydration toward the base of the hanging wall. On the other hand, fluids should be more abundant below the plate interface, sourced from thermally immature, smectite-rich, Shikoku Basin sediments.

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