Synthesis Of Results From Scientific Drilling In The Indian Ocean

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28. SEDIMENT GEOCHEMISTRY, CLAY MINERALOGY, AND DIAGENESIS: A SYNTHESIS OF DATA FROM LEG 131, NANKAI TROUGH[1]

Michael B. Underwood,[2] Kevin Pickering,[3] Joris M. Gieskes,[4] Miriam Kastner,[4] and Robert Orr[2]

ABSTRACT

This paper presents a synthesis of data from X-ray diffraction analyses of clay minerals and X-ray fluorescence analyses of bulk mudstones from Ocean Drilling Program Site 808. The samples come from three closely spaced holes drilled through the toe of the Nankai accretionary prism offshore Shikoku, Japan. Detrital assemblages of clay minerals are unusually uniform throughout the Nankai trench-wedge facies. Illite is the most abundant detrital clay mineral, followed by chlorite, smectite, and traces of kaolinite. Relative percentages of smectite increase within the upper subunit of the Shikoku Basin stratigraphy. This subunit contains abundant layers of volcanic ash, and the corresponding change in clay mineralogy probably was caused by synvolcanic weathering in source areas during the Pliocene, together with in-situ alteration of disseminated glass shards within the Shikoku Basin.

At a depth of ~555 mbsf, the detrital and/or authigenic smectite component begins its transformation to illite/smectite mixed-layer clay. With increasing depth below this horizon there is a monotonic increase in illite interlayers. The onset of illitization occurs at an estimated temperature of ~65°C. Ordered (R = 1) illite/smectite interlayering first appears at depths of ~1220 mbsf (<2-µm size fraction) and ~1100 mbsf (<0.2-µm size fraction). The depth interval of the smectite-to-illite transformation coincides with a reduction in pore-water chlorinity; however, the absolute abundance of smectite appears to be insufficient to account for the changes in aqueous chemistry via in-situ dehydration reactions. Instead, significant volumes of diluted pore water probably were transported to Site 808, either from sources located deeper in the accretionary prism (where bulk mudstone porosities are lower) or from lateral sources where mudstones originally deposited in the Shikoku Basin may contain higher percentages of smectite. Significantly, we did not detect any anomalies in clay mineralogy or clay-mineral diagenesis within or near the décollement zone (945–964 mbsf).

X-ray fluorescence analyses show that hemipelagic muds and mudstones at Site 808 are chemically uniform throughout most of the section. There are no geochemical perturbations, for example, within the décollement zone. Data from interbeds of volcanic ash demonstrate that the chemical effects of mud/ash dissemination and/or in-situ alteration of pyroclastic material are limited. In addition, ash layers are chemically heterogeneous within Unit III and Subunit IVa, which indicates that tephra was transported from a variety of andesitic to rhyolitic sources on the Japanese Islands during the Pliocene. In contrast, Miocene rocks of Unit V display a clear chemical divergence (little mixing) between rhyolitic tuffs and interbeds of multicolored mudstone.

The most significant geochemical anomaly at Site 808 occurs well below the décollement zone between 1087 and 1111 mbsf. Variegated mudstones in this interval contain unusually high ratios of MgO/Al_2O_3, Fe_{total}/Al_2O_3, MnO/Al_2O_3, and CaO/Al_2O_3, together with high concentrations of Ba, Y, Sr, La, and Ce. We attribute this anomaly to hydrothermal alteration and/or precipitation of Ca-carbonate, siderite, barite, and related minerals, but we do not know when the event occurred. Fluid migration may have taken place during late Miocene time early in the depositional history of Shikoku Basin (i.e., above newly formed oceanic lithosphere) or during the Holocene as fluids advected through the Nankai accretionary prism.

INTRODUCTION

Site 808 of the Ocean Drilling Program (ODP) is located near the base of the Nankai accretionary prism of southwest Japan (Fig. 1), close to where the extinct backarc spreading ridge of the Shikoku Basin intersects the deformation front (Le Pichon et al., 1987; Taira et al., 1992). Cores recovered from Holes 808A, 808B, and 808C have been grouped into five major sedimentary facies units, as well as several subunits, which range from Miocene to Quaternary in age (Fig. 2). The uppermost facies comprises a thin carapace of trench-slope sediments that accumulated above accreted trench and abyssal-plain deposits. The chaotic style of deformation displayed by these deposits probably was caused by submarine slides. The trench-wedge facies (Unit II) is characterized by an upward-coarsening and upward-thickening succession of terrigenous turbidites, with interbeds of hemipelagic mud. The trench-wedge deposits reach a total structural thickness of approximately 600 m; partial duplication of the section has occurred because of offset along the frontal thrust of the accretionary prism (Fig. 2). A transitional facies (Unit III) displays sedimentologic characteristics of both the outer marginal trench wedge and the upper part of the abyssal-plain succession, in that it contains both thin silty turbidites and layers of volcanic ash, together with the dominant lithology of hemipelagic mudstone. The composition and provenance of these trench-slope and trench-wedge deposits have been discussed at length by Underwood et al. (this volume).

Unit IV (Shikoku Basin deposits) begins at about 620 mbsf (Fig. 2). These abyssal-floor sediments are dominated by strongly bioturbated hemipelagic mudstones. Subunit IVa contains abundant, well-defined layers of volcanic ash and lithified tuff, whereas Subunit IVb is nearly devoid of discrete volcaniclastic interlayers. The basal décollement zone of the Nankai accretionary prism occurs at a depth of 945–964 mbsf at Site 808, within the middle of the hemipelagites of Subunit IVb. The lowermost unit of the sedimentary succession (Unit V) contains thick layers of graded and cross-stratified rhyolitic tuff and variegated hemipelagic mudstone and claystone of middle Miocene age (13.6 Ma). Basaltic basement of the Shikoku Basin occurs at a depth of approximately 1290 mbsf (Fig. 2).

In total, the stratigraphic succession outlined above follows the paradigm of subduction-zone sedimentation and tectonics (e.g., Piper et al., 1973; von Huene, 1974; Seely et al., 1974). The segment of subducting oceanic plate penetrated at Site 808, with its cover of

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[2] Department of Geological Sciences, University of Missouri, Columbia, MO 65211, U.S.A.
[3] Department of Geology, University of Leicester, Leicester LE1 7RH, United Kingdom.
[4] Scripps Institution of Oceanography, University of California, La Jolla, CA 92093, U.S.A.

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