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2. Data Report: Sedimentological and Petrographic Characteristics of Volcanic Ashes and Siliceous Claystones (Altered Ashes) from Sites 1173, 1174, and 1177, Leg 190[1]

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INTRODUCTION

Leg 190 was the first of a two-leg program across the Nankai accretionary prism and Trough, offshore Japan, aiming to evaluate existing models for prism evolution and to constrain syntectonic sedimentation, deformation styles, mechanical properties, and prism hydrology (Moore, Taira, Klaus, et al., 2001; Moore et al., 2001). More than 400 volcanic ash and siliceous claystone (altered ash) layers were penetrated and sampled during drilling of the six sites from two transects across the accretionary prism (Sites 1173–1178). In sites from the subducting Shikoku Basin (Sites 1173 and 1177) and in the trench axis (Site 1174), recognition of ash layers and diagenetically altered ashes was initially important in defining major lithostratigraphic units. However, it is clear that understanding the diagenesis of the volcanic ashes has considerable implications for prism evolution, mechanical properties, prism hydrology, geochemistry, and fluid flow in the accretionary prism and associated subducting sediments (cf. Masuda et al., 1996). Particle size, chemical composition, temperature, depth of burial, and time are all thought to be factors that may affect volcanic ash diagenesis and preservation (Kuramoto et al., 1992; Underwood et al., 1993). The overall aim of this research is to evaluate factors influencing volcanic ash diagenesis in the Nankai Trough area. This data report pre-

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sents just the results of the sedimentological and petrographic analysis of the volcanic ashes and siliceous claystones from Sites 1173, 1174, and 1177. It is anticipated that when the results of additional geochemical analysis of these lithologies is available a more meaningful evaluation of factors influencing volcanic ash alteration will be possible.

METHODOLOGY

Sedimentological and petrographic characteristics of volcanic ashes and siliceous claystones from Sites 1173, 1174, and 1177 were determined from a combination of core, smear slide and thin section observations and scanning electron microscopy (SEM) analysis.

Sedimentological description of cores was undertaken on board ship, using the standard Ocean Drilling Program (ODP) procedure (Mazzullo and Graham, 1988). All sedimentological information was drawn up as measured sections on visual core description (VCD) sheets and then using the AppleCORE software onto barrel sheets (Moore, Taira, Klaus, et al., 2001). The onboard lithologic and textural determination of volcanic ash (tuff or lapilli) and siliceous claystone beds followed Mazzullo et al., 1988. For all the volcanic ash and siliceous claystone beds encountered, information concerning their bed thickness, bed contacts, color, grain size, and sedimentary structures was described and tabulated (Tables T1, T2, T3).

Preparation and preliminary petrographic analysis of smear slides was undertaken on board ship (Moore, Taira, Klaus, et al., 2001). The results of the semiquantitative analysis of smear slides of volcanic ashes and siliceous claystones is tabulated (Tables T1, T2, T3). Visual percentage estimates for constituent components were grouped into the following categories:

D = dominant (>50%).
A = abundant (>20%–50%).
C = common (>5%–20%).
P = present (>1%–5%).
R = rare (>0.1%–1%).
T = trace (<0.1%).

Thin sections of volcanic ash and siliceous claystones were made at Durham University. Considerable problems, related to swelling and cracking of samples, were encountered during the preparation of many of siliceous claystone thin sections. To enable meaningful comparison with the smear slide data, components present in the thin sections were grouped into the same visual percentage categories as above. A further examination of all smear slides and thin sections was undertaken to determine grain sizes of samples. Using the same categories as for the components, the visual percentage estimates of the following grain sizes were recorded: coarse sand and gravel, medium sand, fine sand, silt, and clay (Tables T1, T2, T3). Following post-shipboard analysis of the smear slides, the visual percentage estimates for constituent components have been updated and the values presented herein (Tables T1, T2, T3) differ slightly from those given in Moore, Taira, Klaus, et al., 2001. For SEM analyses, undertaken at Durham University, samples were oven dried and gold coated.

To enable semiquantitative evaluation of the degree of diagenetic alteration of volcanic ashes, a number of additional features were re-

T1. Petrographic characteristics and alteration, Site 1173, p. 7.

T2. Petrographic characteristics and alteration, Site 1174, p. 8.

T3. Petrographic characteristics and alteration, Site 1177, p. 9.

corded during smear slide, thin section, and SEM analysis (cf. Masuda et al., 1996; Marfil et al., 1998). These features included percentage alteration to clay minerals (0%–30%, 30%–65%, and 65%–100%) of clay/silt size and sand/gravel sized, glass shards, and pumice. It was realized that distinguishing between detrital and authigenic clays might be difficult through petrographic analysis. The unaltered and ash samples contain <0.5% clay. Partially altered ash samples also contain <0.5% disassociated clays. The amount of detrital clay within the altered and unaltered ash samples was therefore taken to be minimal. The only known exception to this was a vitric tuff containing abundant nannofossils at Site 1174. Although it is possible that rare highly altered ash beds may have contained >0.5% detrital clay, it is inferred that a rare spurious result from an isolated bed would not alter the overall trend in results. The presence of irregular scalloped margins to glass shards and alteration of feldspars to clay minerals was also recorded (Tables T1, T2, T3). Through petrographic analysis the volcanic ashes were classified based on predominant vitric (glassy), crystal, or lithic components (cf. McPhie et al., 1993).

RESULTS

Volcanic Ashes and Siliceous Claystones

The presence of volcanic ashes and siliceous claystones was used to help define the boundaries of major lithostratigraphic units. The deepest volcanic ash layer with abundant, recognizable volcanic glass shards or pumice was defined as demarking the lowermost bed of the upper Shikoku Basin facies. However, this lithostratigraphic unit boundary is not a sharp diagenetic boundary, since alteration of volcanic ashes is common in the lower part of the upper Shikoku Basin facies. Recognizable glass shards or pumice fragments are present in some of the siliceous claystones in the lower Shikoku Basin facies and the volcaniclastic facies (or volcaniclastic-rich facies; Site 1177). The boundary between the upper and lower Shikoku Basin facies occurs at different depths (Site 1173: 344 meters below seafloor [mbsf]; Site 1174: 661 mbsf; and Site 1177: 401 mbsf) and in sediments of different ages (Site 1173: Pliocene; Site 1174: Pliocene; and Site 1177: late Miocene). The lithologic distinction between the upper and lower Shikoku Basin facies results from differences in ash diagenesis and variability in pyroclastic input (Moore, Taira, Klaus, et al., 2001).

Abundant volcanic ashes are interbedded with hemipelagic clays in the upper Shikoku Basin facies. Less commonly, ashes are interbedded with hemipelagic clays and silt or sand turbidites in the trench-wedge facies. Volcanic ashes with recognizable glass shards are also present in the volcaniclastic or volcaniclastic-rich facies, where they are interbedded with hemipelagic mudstones. Siliceous claystones are interbedded with hemipelagic mudstones and are found in the lower Shikoku Basin facies, the lower part of the upper Shikoku Basin facies, and the volcaniclastic (or volcaniclastic-rich) facies.

Sedimentologic Characteristics of Volcanic Ashes and Siliceous Claystones

Layers of volcanic ash are mostly very thinly bedded (1–3 cm thick) to medium bedded (10–30 cm thick); however, beds may be up to a few meters thick. The basal contacts of beds are sharp and irregular or plane-parallel, and upper contacts are gradational and irregular. Color varies considerably between different ashes and within individual beds. Colors recorded include whites, pinks, grays, and greens. Particle size varies from clay/silt to coarse sand and gravel-grade lapilli. Many of the beds fine upward, although some beds include basal units that coarsen upward before fining upward. Diffuse plane-parallel laminae are present in some volcanic ash beds. The upper gradational top passing into hemipelagic clays is often affected by bioturbation.

Siliceous claystones show a number of similar sedimentological characteristics to the volcanic ashes. Beds are very thinly bedded to medium bedded. Lower bed contacts are sharp and plane-parallel to irregular, and upper bed contacts are gradational and irregular. Although most of the siliceous claystones are gray or green, white and pink beds are also present. Most particles are clay/silt sized, although coarse sand-grade material is rarely present in the base of some beds. Sedimentary structures were mostly absent from the siliceous claystones, although rare faint lamination was observed. A number of the beds had been affected by bioturbation.

Petrographic Characteristics of Volcanic Ashes and Siliceous Claystones

Initial results reveal that the volcanic ashes are predominantly vitric or pumiceous tuffs with a rhyolitic to rhyodacitic composition. Vitric tuffs contain variable amounts of secondary components such as pyrite, quartz, feldspar, biotite, or amphiboles and, in some cases, would be classified as crystal-rich vitric tuffs. In the trench-wedge facies and the upper part of the upper Shikoku Basin facies, volcanic ashes are predominantly unaltered. Low amounts of hemipelagic clays intermixed with volcanic ashes are difficult to distinguish from minor alteration of silt/clay-sized glass particles. It is therefore difficult to define the onset of ash alteration, and some of the results where volcanic ashes show between 0% and 30% alteration of clay/silt-size glass particles may be spurious (Tables T1, T2, T3). Diagenetic alteration of volcanic ashes typically increases downhole, on passing deeper into the upper Shikoku Basin facies. Within this "zone" of ash alteration, finer-grained lithologies are typically more diagenetically altered than coarser-grained ashes, and the finer-grained beds may be almost completely altered to siliceous claystones. Partially altered coarse-grained volcanic ashes may show between 30% and 65% alteration of clay/silt-grade glassy particles, 0% to 30% alteration of sand/gravel-grade glassy particles, and remaining glassy particles often have irregular scalloped margins due to dissolution.

Siliceous claystones are composed of opal-CT, clay minerals, and zeolites, as well as some of the secondary minerals found in the unaltered ashes. Clay minerals within the siliceous claystones include smectites and mixed-layer clays, based on preliminary X-ray diffraction (XRD) analysis undertaken on board the ship. Many of the siliceous claystones contain minimal or no recognizable glass particles, and it was only on the basis of their sedimentological characteristics and/or inclusion of secondary minerals that they were recognized as altered ash beds. Siliceous claystones that do contain recognizable glassy particles typically show 65% to 100% alteration of silt/clay-sized glassy material and between 35% and 90% alteration of sand/gravel-sized glassy particles. Any remaining glassy particles tend to have highly irregular, scalloped margins due to dissolution. Feldspar crystals present in the siliceous claystone often show partial or near-complete alteration to clay minerals, particularly along cleavage planes.

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Table T1. Core and petrographic characteristics and diagenetic alteration of volcanic ash and siliceous claystone layers, Site 1173. (This table is available in an **oversized format**).

Table T2. Table showing depth, core and petrographic characteristics, and degree of diagenetic alteration of volcanic ash and siliceous claystone layers from Site 1174. (This table is available in an **oversized format**).

Table T3. Table showing depth, core and petrographic characteristics, and degree of diagenetic alteration of volcanic ash and siliceous claystone layers from Site 1177. (This table is available in an **oversized format**).