IODP Expedition 346: Asian Monsoon

Site U1422 Summary

Background and Objectives

Site U1422 is located in the northeastern part of the Sea of Japan/East Sea (JS/ES) at the latitude of 43°45.99′N, 138°49.99′E and a water depth of 3429 m. The site is approximately 40 km to the southwest of ODP Site 795 and near the northeastern edge of the topographic depression of the Japan Basin. The site is mainly under the influence of the Liman (Cold) Current, but may be also slightly influenced by the Tsushima Warm Current (TWC). Although more than one half (1.4 Sv) of the TWC (~2.5 Sv) flows out of the JS/ES through the Tsugaru Strait, which is located approximately 300 km to the south of Site U1422, the rest of the TWC (~1.1 Sv) flows further north and out through the Soya Strait at present. Because the sill depth of Soya Strait, which is ~300 km to the northeast of Site U1422, is only 55 m deep, the influence of the TWC should have been significantly affected by glacioeustatic sea level changes during the Quaternary. Results from previous drilling at ODP Site 795 suggest continuous deposition of hemipelagic sediments since the Middle Miocene, with an average linear sedimentation rate (LSR) of ~55 cm/k.y. for the upper 200 m. The Plio-Pleistocene sediments of Site 795 also show the occasional occurrence of dropstones in the upper 300 m of the sequence, suggesting its appropriateness for ice-rafted debris (IRD) studies.

Although the occurrence of calcareous microfossils is sparse at ODP Site 795, study of benthic microfossils may allow examination of the relation between deepwater ventilation and the nature of the influx through the Tsushima Strait and/or the intensity of winter cooling. The site is also appropriate for reconstruction of eolian dust flux, grain size, and provenance changes since 5 Ma, considering the relatively slow expected LSR of the site. Although the contribution of IRD to the total terrigenous flux may not be negligible, studies on the specific grain size range of eolian dust (4–32 μm) may allow differentiation of the eolian dust component from IRD and other terrigenous components.

Site U1422 is the northernmost site of the latitudinal transect targeted by Expedition 346 and is also the deepest site of the depth transect. The location of Site U1422 was

selected specifically to identify the timing of the onset of IRD events and to reconstruct temporal variations in its intensity and frequency. Because sea ice formation in the JS/ES occurred along the northwestern margin due to the strong winter cooling, and strong winter cooling in the northwestern margin of the sea is closely related with the intensity of Siberian High, we expect the intensity of the IRD events to reflect the strength of the East Asian winter monsoon (EAWM). Therefore, at Site U1422 we hoped to reconstruct the EAWM intensity through examination of IRD abundance and distribution along the northern latitudinal transect in the JS/ES. At present, stronger winter monsoon wind produces deepwater, called Japan Sea Proper Water (JSPW), through sea ice formation in the northwestern part of the Japan Sea. Consequently, sea ice formation and deepwater ventilation could also reflect winter monsoon intensity. Previous studies described the occurrence of millennial-scale IRD events in the northern part of the Sea of Japan/East Sea during the last 160 k.y. Correlation of these IRD data with the sediment lightness (L*) of a core taken before the cruise (Core MD01-2407) shows that many of these IRD events coincide with intervals of high L* values, further suggesting intense deepwater ventilation that in turn coincides with Heinrich events.

Principal Results

Five holes were cored at Site U1422 using the advanced piston corer (APC) and nonmagnetic core barrels. The deepest one, Hole U1422C, penetrated to a maximum subbottom depth of 205 m CSF-A. The sedimentary succession recovered at Site U1422 extends from the Pliocene to Holocene and above ~90 m CSF-A closely follows the lithologic sequence previously identified at ODP Site 795, where the lithofacies are dominated by clays, silty clays, and diatomaceous clays with minor volcaniclastic material.

The shipboard lithostratigraphic program involved visual assessment of sediment composition, color, sedimentary structures, and bioturbation intensity, supplemented by petrographic analysis of smear slides and bulk mineralogic analysis by X-ray diffraction. These were used to describe and define the facies and facies associations from each hole. A total of 212 smear slides were examined from Hole U1422C to help determine lithologic names, while fewer were taken in Holes U1422D (49) and U1422E (27). From Hole U1422C, 36 samples were selected for XRD analysis for

mineralogic analysis.

The sedimentary section is divided into two major lithologic units (Units I and II), distinguished on the basis of sediment composition. Unit I consists of Holocene to uppermost Pliocene silty clay and clay with lesser amounts of diatom-bearing and diatom-rich silty clays. Minor calcareous layers containing foraminifers and carbonate nodules are rare, but present. Unit I is also characterized by alternating, decimeter-scale color banded bedding interpreted to represent differences in the organic carbon content of the dominant silty clays, and clays. Dark, organic-rich intervals (dark gray to dark olive gray) are interspersed between lighter colored, organic-poor intervals (light green to light greenish gray). The frequency of the alternating dark and light color variations allows further subdivision of Unit I into Subunits IA and IB, with Subunit IA having a much higher frequency of dark layer occurrence than Subunit IB. Unit II is distinguished from Unit I by the significant increase in diatom content and the presence of centimeter- to decimeter-scale sandy turbidites, the frequency of which increases with depth.

A composite section and splice were constructed for Site U1422 in an effort to establish a continuous sediment sequence using Holes U1422A through U1422E. Splicing among these holes enabled us to construct a continuous stratigraphic sequence, with the exception of two gaps at ~85 and ~115 m CCSF-D, from the sea floor to the bottom of Core 346-U1422C-18H (144.1 m CSF-A). From that depth downward, only sediment from Hole U1422C was recovered. The composite section for Site U1422 consists of four segments, from 0 to ~85 m, ~85 to ~115 m, ~115 to ~156 m, and ~156 to 217 m (all CCSF-D).

The age assignments at Site U1422 are primarily based on siliceous microfossils. The radiolarian assemblages show moderate to good preservation, except in the interval between 52 and 78 m CSF-A. The radiolarian stratigraphy spans the interval from the *Cycladophora sakaii* Zone (Pliocene) to the *Botryostrobus aquilonaris* Zone (late Pleistocene). The diatom assemblage is generally moderate to well preserved, although there are several intervals in which valve preservation is poor to moderate. The diatom stratigraphy spans the interval from Zone NPD 12 (Pliocene) to Zone NPD7 (late Pleistocene). The nannofossil, radiolarian, and diatom datums and zonal schemes generally agree, with minor inconsistencies.

Calcareous nannofossils are rare and sporadically distributed in the upper 40 m of the sequence. Planktic foraminifers are also rare to absent, with moderate to poor preservation throughout most of the succession, yet are abundant in the thin calcareous layers that are interpreted to be turbidites. No in situ planktic foraminifer zones were documented due to assemblage reworking. Benthic foraminifers occur intermittently throughout the succession and in general are poorly preserved. The overall benthic foraminifer assemblage composition indicates lower bathyal to abyssal paleodepths. The rare occurrence of agglutinated benthic foraminifers perhaps is due to unfavorable dysoxic conditions at the seafloor.

Paleomagnetic investigations involved the analysis of discrete samples and of the natural remanent magnetization (NRM) of the archive half of the core sections. A variety of measurements were made in the different holes to accommodate core flow and generate the most useful data set. The intensity of NRM ranges from ~10^{-6} to 10^{-2} A/m. The magnetic intensity in Hole U1422C is on the order of 10^{-2} A/m in the first ~7 m, and the intensity gradually decreases with fluctuations from 10^{-2} to 10^{-6} A/m between ~7 m to 86 m, and then increasing towards to the bottom. The Brunhes/Matuyama polarity transition (0.781 Ma) is observed at 37.5, 32.3, and 33.35 m CSF-A in Holes U1422C, U1422D and U1422E, respectively. The Jaramillo Subchron (C1r.1n) (0.988–1.072 Ma) is observed at 41.8, 41.5 and 41.8 m CSF-A in Holes U1422C, U1422D and U1422E, respectively.

The geochemistry program aimed to characterize the interstitial water chemistry and to construct an initial geochemical stratigraphy of total organic carbon (TOC) and total inorganic carbon (TIC) as related to carbonate content. In the upper portion of Unit I, TOC varied from 1 weight % (wt%) to 4 wt%. Below Unit I, TOC values were less than 1 wt%. Carbonate content in general was less than 2 wt%, expect for discrete intervals with elevated values greater than 20 wt%. The sulfate methane transition (SMT), as clearly identified by interstitial water analyses, occurs just below 30 m CSF-A. The methane content of head space samples also rapidly increased at this level from 100 ppm to >10,000 ppm. Further analyses of major and minor metals from interstitial waters indicate that the diagenesis of organic matter and the formation of authigenic carbonates dominate downhole geochemical processes.

Physical property measurements show high variations that reflect the various

lithologies and accompanying diagenetic processes. In Unit I, cyclical variability in density and NGR appears to be driven by the occurrence of thick, massive organic-rich dark layers, while in Unit II the more subdued variability is largely due to terrigneous clastics from turbidites and biogenic silica from diatoms. Magnetic susceptibility is strongly influenced by redox processes with a severe muting of the signal below the SMT. *P*-wave and shear stress data collection was strongly affected by degassing of the sediments, which lead to the development of microfractures in the core. The reflectance data quantifies the variegated colors of the diverse lithological sequences at this site, and provides the opportunity for the decimeter- to centimeter-scale correlation for Unit I between holes at this site, and potentially for future sites.

Successful temperature measurements were made at five depths using the APCT-3 tool, from the mudline to 115.8 m CSF-A in Hole U1422C. The measured geothermal gradient is 134°C/km. The calculated heat flow value using this gradient and measured thermal conductivities is 120 mW/m^2.