IODP Expedition 346: Asian Monsoon

Site U1425 Summary

Background and Objectives

Site U1425 is located in the central part of the Sea of Japan/East Sea at 39°29.44′N, 134°26.55′E and a water depth of 1909 m. The site is situated in the central part of a northeast-southwest oriented graben in the middle of Yamato Bank. Site U1425 is located ~60 km to the southwest of ODP Site 799 that also sits within the graben. A major difference between these two sites is that Site 799 is located in the deepest part of the graben and Site U1425 is situated on a terrace that is one step higher than the bottom of the graben. The topographic setting of Site U1425 was chosen to minimize the influence of turbidites which were numerous at Site 799.

Site U1425 is the northernmost site of the southern half of the Expedition 346 latitudinal transect, and the mid depth site of the depth transect. Preliminary site survey results suggested that Site U1425 was characterized by very slow yet continuous sedimentation (4 cm/k.y.) during the last 600 k.y., which is ideal for detecting the contribution of eolian dust from the Asian continent. Based on the relatively low geothermal gradient of ~100°C/km (as observed at nearby Site 799), the opal-A/opal-CT boundary at Site U1425 was predicted to be at ~400 m. We expected this to allow recovery of unconsolidated sediment back to 10 Ma or older permitting reconstruction of eolian dust flux and provenance changes over this period. In combination with the other sites in the Sea of Japan/East Sea, it will be possible to reconstruct changes in the position of the atmospheric Westerly Jet stream axis during the last ~5 Ma.

Site U1425 is located on the subpolar front in the Sea of Japan/East Sea and under the influence of the first branch of the Tsushima Warm Current (TWC) during summer. Sediments from Site U1425 will be used to reconstruct sea surface temperature changes associated with the north-south movement of the subpolar front that is considered to be influenced by the strength of TWC. In addition, the sea ice margin may have reached the site location during glacial periods and the sedimentary record at this site will help constrain the southern limit of ice-rafted debris (IRD) events. Together with results from Sites U1422–U1424, Site U1425 will enable us to reconstruct temporal changes in the southern limit of sea ice in the Sea of Japan/East Sea during the last 4 Ma. Lastly, we will reconstruct changes in deep water oxygenation and calcium carbonate compensation depth (CCD) during the last 4 Ma by combining the results from the Expedition 346 depth transect sites.

Principal Results

Four holes were cored at Site U1425 using full- and half-length advanced piston corer (APC) and the extended core barrel (XCB) systems. Hole U1425A was terminated after the first core because the core barrel was recovered full, missing a reliable sea floor determination. Hole U1425B was cored to 407.2 m. In Hole U1425C was only cored to 25 m because this hole was dedicated for post-expedition optically stimulated luminescence (OSL) dating. Hole U1425D was cored to 431 m. A total of 135 cores obtained 502.6 m of sediment (105% recovery). In Hole U1425B, four formation temperature measurements were performed and downhole wire log data was obtained to 403.2 m.

The sedimentary succession recovered at Site U1425 extends from the Miocene to the Holocene and is dominated by clays, silty clays, diatom ooze, and claystones. There are numerous discrete tephra (i.e., volcanic ash) layers throughout the sediment record and volcaniclastic material represents a minor component of the lithology. The section is divided into four major lithologic units (Units I, II, III, and IV), distinguished on the basis of sediment composition, and in particular the abundance of biosiliceous and clay fractions.

Unit I (Mid-to-Late Pleistocene to Holocene) consists of clay and silty clay with small amounts of diatom bearing and diatom rich clays. Unit I is further divided into two subunits (Subunits IA and IB) based on the frequency of alternating dark brown (organic rich) and light greenish gray (organic poor) clay intervals. The regularity of this color banding decreases from Subunit IA to Subunit IB.

Unit II (Late Miocene to Early Pleistocene) is distinguished from Unit I based on a significant increase in diatom content relative to terrigenous material, as well as an increase in bioturbation. This unit is further subdivided into two subunits (Subunits IIA and IIB). Subunit IIA is composed of diatom-bearing and diatom-rich clays that fluctuate in clay content. This is reflected by regular color banding in Subunit IIA.

Subunit IIB is dominated by a brownish diatom ooze, with diatoms making up to >70% of the sediment. Well-lithified dolomite beds and concretions are also present throughout Unit II.

Unit III (Miocene) is divided into two subunits. Subunit IIIA is composed of alternating layers of heavily bioturbated diatom ooze, clayey diatom ooze and diatom rich clays. These lithofacies show decimeter- to meter-scale variability between dark gray and gray, but the changes in color can be subtle. Subunit IIIB is characterized by gray siliceous claystones with occasional parallel laminations, burrows, and carbonate concretions. The transition from Subunit IIIA to Subunit IIIB is defined by the diagenetic loss of biosiliceous material and the formation of siliceous claystone. Below this transition, there is evidence for the dissolution of biogenic opal-A and re-precipitation of opal-CT. However, poor recovery in Subunit IIIB makes a detailed description of lithological changes difficult.

Thirty-seven datums were identified based on siliceous and calcareous microfossils. Nannofossils are present in Pleistocene sediments above ~56 m CSF-A, but are absent or rare below this depth. Radiolarians are generally common to abundant throughout the sequence, although they are rare or absent below 351.2 m CSF-A. Diatom abundance is generally low above ~66 m CSF-A, and increases downhole. The scarcity of freshwater diatoms combined with high abundances of phytoliths suggests wind transportation from land. The complete dissolution of diatoms and the rare occurrence of radiolarians near the base of the succession coincide with the opal-A/opal-CT boundary transition. Planktic foraminifers are mainly confined to the upper part of the succession (above ~131 m CSF-A), generally indicating cold and restricted environments. Benthic foraminifers indicate bathyal paleodepths throughout the Pleistocene to Miocene succession. The highly variable composition of the benthic assemblages suggests episodic oxygen depletion and intense carbonate dissolution at the seafloor, particularly during the Pliocene and Miocene.

A composite section and splice were constructed using Holes U1425B and U1425D to establish a continuous sediment sequence, with the exception of three potential gaps, from the sea floor to the bottom of Core U1425B-51H (336.91 m CSF-A). From that depth downward, poor core recovery in both holes prohibited us from constructing a composite section. Sedimentation rates at Site U1425 range from 25 to 44 m/m.y., and are lower in Unit IB, IIA, and IV, moderate in Unit IA, and higher in Unit IIB and III.

Similar to previous sites drilled on Expedition 346, the accumulation of organic matter and its subsequent microbial diagenesis strongly affects the geochemistry at Site U1425. Sediment in the upper ~200 m CSF-A averages ~1 wt% organic carbon. In the upper 1 m, reactions between this organic matter and metal oxides lead to maxima in dissolved Mn and Fe, along with increases in bicarbonate, ammonium, and phosphate. With continued burial, organic matter reacts with dissolved sulfate, which releases additional bicarbonate, ammonium, and phosphate to interstitial water. Much of the organic matter decomposition at Site U1425 occurs through sulfate reduction, as evident by the detailed concave-upward sulfate profile that extends to zero concentration at 60 m CSF-A. Below 60 m, methane concentrations slowly rise, eventually surpassing shipboard (1 atm) saturation conditions at ~150 m CSF-A. Dissolved silica concentrations steadily increase below the seafloor until ~320 m CSF-A, where upon they decrease rapidly, presumably because opal-A is transforming to opal-CT.

Physical properties measured at Site U1425 generally show trends that follow the lithostratigraphy. Magnetic susceptibility, bulk density, and NGR have higher values in lithostratigraphic Unit I than in lithostratigraphic Unit II, whereas porosity and water content show an opposite trend. *P*-wave velocity and shear strength generally increase with depth due to sediment compaction, although shear strength data are highly scattered in the highly diatomaceous layers below ~80 m CSF-A. Color reflectance shows higher variation in lithostratigraphic Unit I than Unit II, and the variations are closely related to the lithology of Unit I, which consists of alternating very dark brown to black organic-rich bands and lighter olive to green colored hemipelagic sediments. All physical property values, with the exception of magnetic susceptibility and grain density, are substantially different in Unit IV, which coincides with the opal-A/-CT transition zone. Bulk density, NGR, and *P*-wave velocity increase, and there are complementary decreases in porosity and water content. From Unit III into Unit IV through the opal-A/-CT transition zone, the physical properties change as follows: GRA bulk density, +0.23 g/cm^3; discrete bulk density, +0.22 g/cm^3; NGR counts, +12.2 cps; *P*-wave velocity, +52.6 m/s; porosity, –13.1%; and water content, –15.6%.

Paleomagnetic studies focused on the measurement of natural remanent magnetization of archive split core-halves. NRM of archive-half core sections from Hole U1425B was measured before and after 20 mT alternating field (AF) demagnetization. Due to increased core flow, NRM of core sections from Holes U1425D were only measured after 20 mT AF demagnetization. The FlexIt tool was successfully deployed to orient 12 APC cores in Hole U1425B starting from Core 2H. We measured 35 discrete samples collected from varying depths at Hole U1425B before and after stepwise AF demagnetization with peak fields up to 60 mT, to verify the archive-half core section measurements and to determine the demagnetization behavior of the sediments. NRM intensity of the measured core sections after 20 mT demagnetization is on the order of 10^{-3} to 10^{-2} A/m for the top ~50 m CSF-A, and decreases down core to ~10^{-5} to 10^{-4} A/m below ~50 m CSF-A. The Brunhes/Matuyama boundary (0.781 Ma) is recorded at ~33.7 m CSF-A in Hole U1425B and at ~34.2 m CSF-A in Hole U1425D. Both the Jaramillo (0.988–1.072 Ma) and the Olduvai (1.778–1.945 Ma) subchrons were identified. The Matuyama/Gauss boundary (2.581 Ma) was recorded at ~87.8 m CSF-A in Hole U1425B, and at ~85.2 m CSF-A in Hole U1425D. Below ~110 m CSF-A in both holes, NRM intensity is weak and is generally on the order of 10^{-5} A/m. Increased coring disturbance, strong drill string overprint, and the largely scattered paleomagnetic directions make magnetostratigraphic interpretations difficult for the deep part of the holes.

Downhole wireline log measurements were made in Hole U1425B to 403.2 mbsf using the Paleo-combo tool string, which recorded spectral gamma ray, caliper, magnetic susceptibility, resistivity, lithologic density logs; and the FMS-sonic tool string, which recorded resistivity images of the borehole, sonic velocities, and natural gamma data. Each logging tool string was run twice in the hole to ensure the quality of the logging data. The logged interval was divided in three Logging Units (Log Unit 1: from the base of the drill pipe to 244 m WSF; Log Unit 2: from 244–338 m WSF, and Log Unit 3: 338 m WSF to the bottom of the hole). The combination of logs closely reflects the lithological changes in the recovered cores, including dolomite and ash layers. Preliminary inspection of the data has also revealed apparent cyclicities in the logs collected by the two logging tool strings below ~244 m WSF, mainly reflecting variation in diatom content relative to terrigenous clays. A shift toward higher density and resistivity is observed ~340 m WSF, corresponding to the diagenetic boundary from biogenic opal-A to opal-CT. Successful formation temperature measurements were made using the APCT-3 tool at four depths, including the mudline, down to 94.3 m CSF-A in Hole U1425B. The measured geothermal gradient was 104°C/km and the calculated heat flow value was 96 mW/m^2. This geothermal gradient is slightly higher than the 98°C/km calculated for ODP Site 799.