IODP Expedition 403: Eastern Fram Strait Paleo-Archive

Week 6 Report (7–13 July 2024)

Operations

The vessel completed the 138 nmi transit in 11.5 h at an average speed of 12 kt. Thrusters were down and secure, and the vessel was in dynamic positioning (DP) mode at 0743 h on 7 July 2024, beginning operations at Site U1621 (proposed Site BED-01A). An advanced piston corer/extended core barrel (APC/XCB) bottom-hole assembly was made up, deployed, and lowered to 1613 meters below sea level (mbsl) based on the precision depth recorder (PDR) reading obtained upon arrival on site. Hole U1621A was spudded at 1320 h and seafloor depth was calculated to be 1638.6 mbsl based on recovery from Core U1621A-1H. APC coring continued to a depth of 86.3 meters below seafloor (mbsf) (Cores 1H–10H). Due to gas in the cores, it was decided to switch to the XCB and use advances of 8.0 m to allow for gas expansion of the cores. The XCB was used to core from 86.3 to 108.8 mbsf (Cores 11X–14X), and coring was switched back to the APC due to poor recovery. The APC was then used to a total depth of 139.8 mbsf. Partial strokes were noted on Cores 16H–18H, thus coring was switched to the half-length APC (HLAPC). The HLAPC was used to advance the hole for Cores 19F–22F to a depth of 157.1 mbsf. Partial strokes were recorded on Cores 21F and 22F. Both cores were advanced by recovery and ended coring with the HLAPC. Hole U1621A was advanced to its total depth of 215.3 mbsf using the XCB (Cores 23X–28X). The rate of penetration slowed and recovery was low for the final two cores when it appeared that the bit had reached a gravel layer. Coring was terminated after Core 28X and the bit was pulled out of the hole, clearing the seafloor at 1745 h on 8 July, ending Hole U1621A. A total of 28 cores were taken over a 215.3 m interval with 180.40 m of recovery (84%). The APC was used for a total of 14 cores over a 117.3 m interval with 124.78 m of recovery (106%). The HLAPC was used for four cores over a 17.3 m interval with 18.06 m of recovery (104%). The XCB took 10 cores over an 80.7 m interval with 37.56 m of recovery (47%). Formation temperature measurements using the advanced piston corer temperature (APCT-3) tool were taken on Cores U1621A-4H, 7H, and 10H. Nonmagnetic core barrels were used on all APC and HLAPC cores.

The vessel was offset 20 m at a bearing of 22°, and Hole U1621B was spudded at 2038 h on 8 July. Based on recovery of Core U1621B-1H, the seafloor depth was calculated to be 1636.5 mbsl. APC and HLAPC coring continued to a depth of 139.9 mbsf (Cores 1H–20F), when the XCB was used to offset coring gaps for the purpose of stratigraphic correlation on Core U1621B-21X, with an advance of 2.5 m. For Core 22F, the HLAPC was deployed but a partial stroke was recorded. The XCB was then used to advance the hole to its total depth of 216.1 mbsf (Cores 23X–33X), where the gravel layer was encountered and coring was terminated. The bit was pulled out of the hole, clearing the seafloor at 0812 h on 10 July, ending Hole U1621B. A total of 33 cores were taken over a 216.1 m interval, recovering 203.39 m of sediment (94%).

The APC was deployed for 10 cores over a 92.9 m interval with 98.16 m of recovery (106%). The HLAPC was deployed for 11 cores over a 51.7 m interval with 55.23 m of recovery (107%). The XCB was deployed for 12 cores over a 71.5 m interval, recovering 50 m of sediment (70%). Nonmagnetic core barrels were used on all APC cores.

The vessel was offset 20 m at a bearing of 22° and Hole U1621C was spudded at 1012 h on 10 July. Based on recovery in Core U1621C-1H, the seafloor depth was calculated to be 1635.9 mbsl. The HLAPC was deployed for Core 2F to adjust for microbiology sampling. The aim was to recover the entire interval of interest with as few core breaks as possible, in order to minimize the potential for contamination and to optimize the workflow in the laboratory. Following this adjustment, APC coring continued to a depth of 147.9 mbsf (Cores 3H–17H), where partial strokes on Cores 16H and 17H signaled APC refusal. The HLAPC was then deployed and Cores 18F–22F advanced the hole to a depth of 171.4 mbsf. The XCB was deployed to advance the hole to its total depth of 207.9 mbsf (Cores 23X–28X), where the gravel layer was encountered and coring was terminated. The bit was pulled out of the hole, clearing the seafloor at 1415 h on 11 July and ending Hole U1621C. The vessel began a 4.6 nmi transit in DP mode to Site U1622. A total of 28 cores were taken over a 207.9 m interval, recovering 195.18 m of sediment (94%). The APC was deployed for 16 cores over a 143.2 m interval with 148.5 m of recovery (104%). The HLAPC was deployed for six cores over a 28.2 m interval with 30.9 m of recovery (110%). The XCB was deployed for six cores over a 36.5 m interval, recovering 15.83 m of sediment (43%). Nonmagnetic core barrels were used on all APC cores.

The bit was pulled to the rig floor during the transit and replaced with an APC roller cone bit. The bit was deployed to depth while in transit and was ready upon arrival at the site. The vessel arrived at what was presumed to be proposed Site BED-02B (Site U1622) at 0012 h on 12 July, completing the transit in 9.6 h at an average speed of 0.5 kt. Hole U1622A was spudded at 0244 h and the seafloor depth was calculated to be 1707.5 mbsl based on recovery from Core U1622A-1H. A gravel layer was encountered almost immediately, causing partial strokes on Cores 4H, 5H, and 6H. The HLAPC was then deployed for Core 7F to a depth of 46.5 mbsf. All cores contained more glacial debris (pebble- and cobble-sized) than anticipated, which led to a review of the site coordinates. It was determined that the site coordinates for proposed Site BED-02B were incorrect and Site U1622 is ~8 km from the approved shot point on Seismic Line CAGE21-1HH-05. Thus, the site was ended. The bit was pulled out of the hole and cleared the seafloor at 1305 h. A total of seven cores were taken over a 46.5 m interval, recovering 46.26 m of sediment (100%). The APC was deployed for six cores over a 41.8 m interval with 41.15 m of recovery (98%), and the HLAPC was deployed for one core over a 4.7 m interval with 5.11 m of recovery (109%). Nonmagnetic core barrels were used on all APC cores. During transit to the next site, the correct coordinates for the approved shot point were determined and the vessel moved to proposed Site BED-02B. The vessel completed the transit at 1800 h in 4.8 h at an average speed of 0.92 kt.

The vessel was on site at 1800 h on 12 July, beginning operations in Hole U1623A. The bit was lowered to 1702.4 mbsl for spudding based on the PDR reading collected on arrival. Hole U1623A was spudded at 1920 h on 12 July and the seafloor was calculated to be 1707.5 mbsl, based on recovery from Core U1623A-1H. Coring continued with the APC to a depth of 58.2 mbsf (Cores 1H–8H). Core 8H was a partial stroke and had 0.43 m of recovery. Switching to HLAPC, Core 9F was a full stroke and another APC was attempted on Core 10H. This resulted in another partial stroke, thus it was decided to continue to advance the hole using the HLAPC from 72.1 to 142.6 mbsf (Cores 11F–25F), where two partial strokes determined HLAPC refusal. The XCB was then deployed to extend the hole from 146.2 mbsf to a depth of 226.0 mbsf at 0000 h on 14 July. Formation temperature measurements were collected with the APCT-3 tool on Cores U1623A-4H, 7H, 10H, and 13F. A total of 35 cores were taken over a 226 m interval, recovering 211.31 m of sediment (94%). The APC was deployed for nine cores over a 67.4 m interval with 67.65 m of recovery (100%). The HLAPC was deployed for 16 cores over a 75.2 m interval with 78.71 m of recovery (105%). The XCB was deployed for 10 cores over an 83.4 m interval, recovering 64.95 m of sediment (78%). Nonmagnetic core barrels were used on all APC and HLAPC cores.

Science Results

Lithostratigraphy

The sedimentology team described all cores from Site U1621 and Hole U1622A. The primary lithologies encountered in Site U1621 are silty clays and clayey silts with few layers of sandy mud, and rare patches of authigenic carbonate. Dispersed clasts of varying grain sizes are present in most cores. In addition, sandy and muddy diamictons are observed in a few cores. The primary lithologies encountered in Hole U1622A are silty clay and a few dispersed layers of sand.

Biostratigraphy

The biostratigraphy group finalized their results from Site U1621, which were analyzed for calcareous nannofossils, dinocysts, diatoms, and planktic foraminifers. The age of recovered sediments ranges from middle to late Pleistocene. The assemblages suggest the environment was mostly Arctic-polar waters with seasonal sea ice during the Pleistocene, and less sea ice in the late Pliocene when conditions were more cold-temperate. Diatoms and planktic foraminifers are recorded more frequently at Site U1621 than at previous sites. Calcareous nannofossils and dinocysts are present throughout, apart from a few barren intervals. All microfossil groups have better recovery and preservation in warmer (interglacial) intervals. Together, the fossil groups indicate a middle to late Pleistocene age for the site. At the end of the week, the group is in the

process of analyzing the biostratigraphy of Sites U1622 and U1623. Preliminary results on planktic foraminifers indicate reworking at Site U1622.

Paleomagnetism

Paleomagnetic and rock magnetic investigations of archive half and discrete cube samples were completed for Sites U1621 and U1622 and are underway for Site U1623. At Site U1621, archive half data indicate the upper 170 m of recovered sediment is normal polarity. In the upper ~100 m at Site U1621, anhysteretic remanent magnetization (ARM) coercivities are much lower and have a smaller range of variability than observed at previous sites, consistent with (titano)magnetite as the dominant remanence carrier. After correlation of physical properties, reproducible paleomagnetic signals between the three holes indicate great potential for higher resolution investigation of paleogeomagnetic signals. Below ~100 mbsf, higher and more variable ARM coercivities may indicate a more complex magnetic mineral assemblage. Significant coring disturbance at Site U1622 limited the usefulness of paleomagnetic data. At Site U1623, extra discrete cube samples from intact biscuits were taken from the XCB cores that seem to capture the polarity boundaries to try and refine their positions, as much of the uncertainty at this stage seems to be related to coring disturbance.

Geochemistry

This week, the geochemistry group analyzed headspace, interstitial water (IW), and carbonate samples from Sites U1621, U1622, and U1623. The group reanalyzed IW samples to confirm the reproducibility of unusual silica results from some cores. Unlike previous sites, Site U1621 has hydrocarbon gas measurements well outside the anomalous zone. Site U1622 has uncharacteristically low methane gas values compared to other sites from this expedition (well below 25 ppmv, mostly below 3 ppmv) for the entire ~46 m sequence. Site U1623 headspace analysis is currently underway, and so far shows similar patterns to Site U1621. Carbonate analysis of Site U1621 suggests that terrestrial organic carbon is more abundant compared to previous sites. Additionally, the source of organic carbon shifts between terrestrial and marine origins with depth. IW data for Site U1621 suggest enhanced organic matter diagenesis and authigenic mineral formation. Pore water alkalinity at Site U1622 is very low and further analyses are underway. Site U1623 IW is being processed and initial results show decreasing salinity downcore and decreasing alkalinity.

Physical Properties

At Sites U1621 and U1622 and Hole U1623A, the physical properties team acquired whole-round scan data on the Special Task Multisensor Logger, Whole-Round Multisensor Logger, and Natural Gamma Radiation Logger. Gamma ray attenuation (GRA) bulk density measurements were not collected for Cores U1621C-1H to 5H for sedimentary ancient DNA (sedaDNA) sampling. GRA measurements resumed in subsequent cores from Hole U1621C. The group

acquired thermal conductivity and moisture and density data at ~5 m intervals. In most intervals, there is a positive linear correlation between magnetic susceptibility (MS), GRA, and natural gamma radiation values, with lower values potentially indicating warm periods. In contrast to previous sites, MS values display fewer outsized peaks, suggesting less postdepositional alteration. This indicates that MS is a valuable tool for correlation between holes drilled at Bellsund Drift. Anelastic strain recovery instruments continued to collect logarithmical recovery of anelastic strain for whole-round samples collected at Site U1620 and at previous sites.

In situ formation temperature measurements were conducted with the APCT-3 and Sediment Temperature 2 tools in Holes U1621A, U1622A, and U1623A, and they show a typical geothermal gradient. Processed downhole logging data for Hole U1620D were received from the Lamont-Doherty Earth Observatory borehole group.

Stratigraphic Correlation

At Site U1621, MS was used as the main parameter for stratigraphic correlation of Holes U1621A, U1621B, and U1621C. A complete composite splice was constructed for 0–195.42 m core composite depth below seafloor (CCSF) with a 21 cm gap that had no overlap between 170.06 and 170.27 m CCSF. Below 195.42 m CCSF-A, core recovery is poor in all three holes and correlation was not possible. At Site U1622 only one hole was drilled, and correlation was not conducted.

Microbiology

The microbiologists targeted sampling at high resolution in two sections from Hole U1612C: Holocene to 30 ka and marine isotope stage (MIS) 5e. In total, 62 horizons over the four cores were sampled. A mudline sample was taken for sedaDNA analysis at Hole U1621A. Age control was determined for the younger section from correlation of MS data to a compiled chronology for the western Svalbard slope. Age control for MIS 5e was also determined through correlation with MS data, this time from comparison to unpublished regional records. Chemical tracer analysis suggests a majority of the samples in the MIS 5e intervals should be uncontaminated by drill fluid. Unfortunately, tracers were not detected in the positive controls for Cores U1621C-1H and 2F, which will likely make negative tracer analysis of this interval void. On the other hand, chemical tracer controls for Cores U1621C-4H and 5H revealed correct dispersal of contamination tracers into the drill fluid, and little penetration of the drill fluid to the center of the core where the sedaDNA was sampled.

Education and Outreach

A highlight of the week was the publication of an Expedition 403 article in *Oceanographic* magazine. The magazine has not provided engagement figures from their website, but from

looking exclusively at our own platforms, the engagement and individual feedback has been extremely positive. The hope is to repeat this success in the next week with the release of the *MOLD* magazine article and video, which has been delivered to the magazine's editor. An editor at *Scientific American* has been contacted for a potential third article, this time on the ice navigators as a means of speaking about this expedition and sea level rise. On social media, the Outreach Officers continued with the "Meet the Science Party" posts to promote the work of the individual scientists, and they also released another face filter focused on foraminifera. An informative video to accompany the filter is to be released this week. Across all social media platforms, we had 14,500 impressions.

Technical Support and HSE Activities

Laboratory Activities

- Staff continued to handle cores with high gas content that resulted in expansion and shattered liners.
- Mac Mini for the video distribution system froze. Rebooting the server fixed the issue.
- The X-Ray Linescan Logger (XSCAN) began making a loud grinding noise and did not move from the start position. After multiple instances of this behavior, the technical staff opened one side panel, cleaned the inside of the XSCAN, greased the gear, and tightened lose screws. The XSCAN worked without incident for a day, but the issue ultimately reoccurred. So far, the issue is not preventing use of the XSCAN.
- Conducting chemical inventory and labeled hazardous chemicals for port disposal.
- Conducting an inventory of oil, lubricants, sealants, and paint.

Application Support Activities

- Helped the technical staff and scientists with minor software issues.
- Worked on the Hyperscan project.
- Worked with shore to fix an issue in the GEODESC software.

IT Support Activities

- Routine server, printer, and computer support tasks were completed.

HSE Activities

- Emergency shower and eye wash stations were tested.