IODP Expedition 403: Eastern Fram Strait Paleo-Archive

Site U1624 Summary

Background and Scientific Objectives

The Isfjorden Drift Site U1624 (proposed Site ISD-01C) is located on the slope proximal area of a plastered sediment drift that developed along the western continental margin of Svalbard under the influence of the northward flowing West Spitsbergen Current (WSC). The Isfjorden Drift has built up over millions of years since the opening of the Fram Strait that determined the onset of the contour current circulation system in the area.

A previous drill site (Ocean Drilling Program Site 986) is located in the deeper, distal slope facing the Isfjorden Drift to examine the onset of glaciation in the European Arctic and to establish the history of the Svalbard-Barents Sea Ice Sheet (SBSIS). Site 986 recovered a sequence of ~2.4 My primarily consisting of fine- to coarse-grained siliciclastic sediments with varying amounts of gravel interpreted as ice-rafted debris and is considered to represent the depositional record after the onset of the Northern Hemisphere Glaciation. The sequence contains a main shift in the glacial style with an increased volume of debris flow sedimentation related with the onset of shelf-edge glaciations in the western margin of Svalbard.

Site U1624 was specifically designed to recover an expanded sedimentary sequence in a slope proximal area to reconstruct the dynamic of the paleo-SBSIS under past oceanographic and climatic forcing after the onset of shelf-edge glaciations. Thanks to its close location to the continental shelf break and former ice sheet terminus during glacial maximum, the Isfjorden Drift contains most of the meltwater events associated with the paleo-ice sheet decay deriving from ocean and climate forcing. Sited between the Bellsund Trough Mouth Fan (TMF) to the south and the Isfjorden TMF to the north, the Isfjorden Drift was partially shielded from the massive glaciogenic input building TMFs, allowing also for a partial preservation of the interglacial contouritic sedimentation that can provide biostratigraphic and paleoceanographic constraints.

Piston cores collected in this area demonstrate that, in addition to the proximal location, the Isfjorden Drift is an excellent setting to recover continuous relatively expanded and dateable sedimentary sequences.

Although located close to the Bellsund Drift, the Isfjorden Drift site will give complementary information on the WSC characteristics and variability, allowing discrimination between climate-driven events related to local or regional effects.

Operations

The vessel made the 71.6 nmi transit from Site U1623 to Site U1624 in 6.06 h, with an average speed of 11.8 kt. Thrusters were down and secured at 0557 h (UTC + 2 h) on 18 July 2024 and the vessel was switched to dynamic positioning (DP) mode at 0600 h, starting operations at Site U1624.

A total of 3.23 d were spent on site, penetrating a maximum depth of 258 meters below seafloor (mbsf), with a combined penetration of 517.3 m. The cored interval of 517.3 m resulted in a recovered length of 464.62 m (90% recovery). Site U1624 consists of three holes that stretch across a 25 m interval (5 m between Holes U1624A and U1624B, and 20 m between Hole U1624B and U1624C). We collected 89 cores in total, with 25% advanced piston corer (APC) use (22 cores), 27% half-length APC (HLAPC) use (24 cores), and 48% extended core barrel (XPC) use (43 cores). To minimize magnetic overprinting on the cored sediment, nonmagnetic collars and core barrels were used for all APC and HLAPC coring. Holes U1624B and U1624C had intervals in which the sediments expanded significantly due to the presence of gas, resulting in recoveries sometimes exceeding 100%. To mitigate the impact of expansion and the potential for core disturbance, and to release the pressure, holes were drilled into the liner, both by the drill crew on the rig floor and by the technical staff on the core receiving platform. In addition, most XCB cores were advanced by 6–8 m to allow for gas expansion of the sediments in the liner.

Principal Results

The sediments of Site U1624 are siliciclastic, primarily composed of soft to firm dark gray silty clay, with coarser intervals containing reddish gray to dark reddish gray sandy mud, and diamicton intervals. The lithologies contain varying amounts of detrital clasts with a range of sizes. Clast abundance ranges from dispersed (<1% of the split core surface) to common (1%–5%) to abundant (5%–30%). When clast abundance was between 1%–30% and clasts >2 cm were encountered and the sediment was poorly sorted, the lithology was designated as a diamicton. Overall, there is a decrease of silty clay and an increase of diamictons with depth. Diamictons dominate the record recovered at the base of Site U1624. Based on the primary (i.e., detrital siliciclastic) lithological characteristics, two lithologic units (I and II) and additional subunits (IA, IB, IIA, and IIB) are defined for Site U1624.

Hole U1624B was primarily used for biostratigraphic analyses of calcareous nannofossils, diatoms, dinocysts, and planktic foraminifers. Calcareous nannofossils are scarce at Site U1624, yet four age markers are identified, indicating the lower half of the record could be older than 0.9 Ma. Diatoms are only found at the very top of the site and do not provide age constraints. The dinocyst assemblages are characteristic of the late Pleistocene but no specific markers were found. The planktic foraminifers show an overall Pleistocene age for Site U1624. The observed

microfossils at Site U1624 are characteristic of Arctic-polar conditions with (seasonal) sea ice. Some dinocyst assemblages also show an interval of relatively warm Atlantic water influence.

Paleomagnetic investigation at Site U1624 focused on measurements of the natural remanent magnetization (NRM) before and after alternating field (AF) demagnetization of the archive half sections and vertically oriented discrete cube samples. All archive half sections were measured except for some that had significant visible coring disturbance and the core catchers. APC and HLAPC archive sections were measured before and after 10 and 15 mT peak AF demagnetization. As XCB cores do not use nonmagnetic core barrels and are more susceptible to the viscous isothermal remanent magnetization drill string overprint, XCB archive half sections from Hole U1624B were measured before and after 15 and 30 mT peak AF demagnetization, and XCB archive half sections from Hole U1624C were measured before and after 30 mT peak AF demagnetization. Sedimentary fabric was likely not preserved in many of the sediments recovered at the depths of XCB coring, as these were often described as diamictons, had high abundance of coarse material, and only rarely displayed intact biscuits of undisturbed sediment. This likely limits the potential for robust paleomagnetic reconstructions from these depths. Unlike most of the sites drilled during Expedition 403, Site U1624 does not display obvious large magnetic susceptibility (MS) peaks that might be associated with higher concentrations of authigenic greigite.

The physical properties measured at this site included MS, gamma ray attenuation (GRA) bulk density, natural gamma radiation (NGR), *P*-wave velocities, and moisture and density (MAD). There is generally good correspondence between data collected at high resolution on the MS loop sensor and data collected at low resolution on the MS point sensor, with the MS point measurements picking up additional peaks in MS that were missed during the averaging in loop sensor measurements. Though some intervals of GRA bulk density are slightly lower than MAD sample density, there is good correspondence between data from high- and low-resolution measurements. Due to the presence of gas and clasts, *P*-wave velocity data are not considered reliable, and there is no detectable signal in either discrete or logger data below ~20 mbsf. Thermal conductivity generally increases with depth and displays oscillations that may be related to compositional differences. Lithostratigraphic Subunit IA is characterized by higher MS and lower NGR and GRA. Subunit IB is characterized by a decrease in average MS values and greater amplitude variability in GRA. Subunit IIA has greater MS and GRA variability with higher modes than Subunit IB. Subunit IIB has the highest GRA and NGR with the lowest MS. Overall, Hole U1624C average MS values have progressively lower magnitudes with depth, in contrast to Expedition 403 northern sites. MS at Site U1624 is less influenced by secondary alteration, and there are more apparent relationships between MS and other physical properties (e.g., NGR). Overall, physical properties at Site U1624 appear to be influenced by oceanographic changes and glaciogenic deposition of dense, coarse, clast-rich deposits.

For the stratigraphic splice, tie points were primarily established based on Special Task Multisensor Logger MS. Below ~150 mbsf, expansion of the sediments resulted in relatively high and variable growth factors with multiple gaps, which likely affected the physical properties (e.g., density) leading to some stratigraphic inconsistencies among holes. A single spliced interval from 0 to 270.167 m core composite depth below seafloor (CCSF) was constructed based on correlations among Holes U1624B and U1624C. The splice is generally defined down to ~210 m CCSF; however, below that depth there are a few relatively large gaps due to poor core recovery in both holes. Wherever gaps occur, the cores are appended according to their growth factor.

Samples for interstitial water (IW) chemistry, bulk sediment geochemistry, and headspace gas were analyzed at Site U1624. The main findings from IW analysis show diagenetic reactions and the influence of variations in the intensity of the overlying bottom water circulation. The sediment geochemistry data revealed high total carbon and $CaCO_3$ peaks in Lithostratigraphic Subunit IIB, likely from authigenic carbonate, and total organic carbon/total nitrogen ratios indicating a mix of marine and terrestrial organic matter. With regard to headspace geochemistry, C_1/C_2 (methane/ethane) ratios stayed well within safe operational limits at this site, and hydrocarbon gas profiles appear to trend with lithology. The intensity of bottom water along the Svalbard margin strongly influences the IW and bulk sediment geochemistry, where downhole variations (e.g., barium, silica), are likely related to weakening and strengthening of bottom water, and thus, sedimentation rate.

During the APC coring in Hole U1624B, in situ formation temperature was measured with the advanced piston corer temperature (APCT-3) probe in Cores U1624B-4H, 7H, 10H, and 14F. Temperature increased almost linearly with depth, and the slope of linear regression provides a typical geothermal gradient for oceanic sediments. For Hole U1624B, the heat flow in the sediments and the temperature at the seafloor were calculated using the measured thermal conductivity in Cores U1624B-1H to 34X and the formation temperature measurements.