IODP Expedition 400: NW Greenland Glaciated Margin

Site U1605 Summary

Background and Objectives

Site U1605A (proposed Site MB-31A) was cored at position 73°33.6421′N, 62°9.0687′W in 529 m of water on the outer shelf of the NW Greenland shelf margin. Constrained by high quality seismic data, the objective was to recover potential marine intervals within packages of horizontal, semicontinuous reflections that aggrade over glacial unconformities within topset strata of the Melville Bugt Trough Mouth Fan (Knutz et al., 2019). Site U1605 captures Seismic Units 7–10 with a target depth just below Seismic Horizon 6, corresponding to 282 meters below seafloor (mbsf; based on average *P*-wave velocity of 2200 m/s). The sequence, considered to be mainly of early–middle Pleistocene age, overlaps stratigraphically with the deepwater Sites U1603 and U1604. The primary lithology was assumed to be compacted diamicton with intervals of sand and pebbly mud, representing marine to glaciomarine deposits, intersected by at least four glacial unconformities. The scientific objectives for drilling Site U1605 are complementary to the deepwater Sites U1603 and U1604, but with an emphasis on testing the hypothesis that the NGrIS underwent significant deglaciation potentially related to exceptionally warm or prolonged "super-interglacials" (Schaefer et al. 2016; Christ et al., 2023). Additionally, multiproxy data from Site U1605 can be used to assess the regolith hypothesis for the change in orbital insolation frequency across the mid-Pleistocene transition (MPT) (Clark and Pollard, 1998).

Operations

Hole U1605A

The vessel transited 39 nmi from Site U1604 to Site U1605, arriving on location at 2200 h on 9 September 2023. Observing that ice was a sufficient distance away from the vessel, the thrusters were lowered and secured at 2224 h and the ship was fully in dynamic positioning (DP) mode at 2229 h. A rotary core barrel (RCB) bottom-hole assembly (BHA) was made up and tripped down. We initially attempted to spud Hole U1605A based on a water depth of 524.1 meters below sea level (mbsl). Following a 3 m advance, the core barrel returned empty. The pipe was lowered and Hole U1605A was spudded at 0340 h on 10 September and recovered 3.2 m from an 8.0 m advance. The seafloor was established as 528.7 meters below sea level (mbsl). Cores U1605A-1R to 47R advanced from 0 to 282 m core depth below seafloor, Method A (CSF-A) and recovered 38.45 m (13.6%). We then began pulling the drill string out of the hole, clearing the seafloor at 1535 h on 13 September. The drill string was tripped up, with the bit at the surface at 1720 h. The drill floor was secured for transit and the thrusters were raised and secured for transit at 1748 h, ending Hole U1605A and Site U1605. The rate of penetration in Site U1605 was highly variable (0.16–28.8 m/h), and averaged 4.56 m/h.

Principal Results

Lithostratigraphy

Site U1605 is on the northwest Greenland outer continental shelf at a modern water depth of 529 m with low-angle, seaward-dipping seismic stratigraphy underlying inferred gravel at the seafloor. Due to low recovery, reporting of lithostratigraphy and depositional history is limited at Site U1605. Magnetostratigraphy and biostratigraphy were restricted by discontinuous sampling and require further interpretation. The recovered sediment is tentatively interpreted as Pleistocene based on seismic stratigraphic constraint.

The stratigraphy of Site U1605 is summarized as one lithostratigraphic unit comprising two subunits (Lithostratigraphic Unit [LSU] IA and LSU IB; younger to older). Named sedimentary lithofacies include massive diamicton and stratified diamicton. A significant proportion of core recovered contained "washed gravel" (a form of core disturbance) with lithologies consistent with clasts present in the diamicton. Of the ~13% recovered, ~8% (~23 m cumulative) is diamicton with the remaining ~5% made up of washed gravel. LSU IA contains the upper ~83 m CSF-A and is composed of massive diamicton and washed gravel. LSU IB extends from 83 to 275.1 m CSF-A (deepest recovery) and consists of massive diamicton, stratified diamicton, and washed gravel.

Micropaleontology

Recovery was consistently poor, and many cores did not produce core catcher sediment samples. Where sediment was recovered, core catcher samples were comprised of diamicton. Despite the indurated nature of the diamicton, the material disaggregated relatively easily. Twelve core catcher samples from the 47 cores of Hole U1605A and one mudline sample were prepared and examined for foraminifera, diatoms, dinocysts, and other palynomorphs. The samples were largely barren of foraminifera and diatoms. Diatoms were visually barren in the majority of the samples, except in the mudline sample which contained rare, poorly preserved diatoms typical of modern Arctic marine environments. Dinoflagellate cysts and other palynomorphs, including Leisopheres (a group of acritarchs), were observed in multiple samples. A mudline sample (~10 g) was collected as a modern DNA reference in Hole U1605A. No samples besides the mudline were collected for sedimentary ancient DNA (sedaDNA) analysis.

Paleomagnetism

Recovery from Site U1605 was poor, containing many intervals of washed gravel. However, where cohesive diamicton was present, paleomagnetic measurements were made on the archive halves with the superconducting rock magnetometer (SRM) and on discrete samples from the working halves, either cut using a parallel saw or collected using J-cubes. The eleven discrete samples were measured after stepwise demagnetization up to an 80 mT peak alternating field (AF) demagnetization. Magnetic fabric assessed by anisotropic magnetic susceptibility (AMS) indicated some potential disturbance of the sedimentary fabric. Natural remanent magnetization

(NRM) and the remanence after 10 mT and 20 mT peak (AF) demagnetization were measured on 16 archive section halves where diamicton was continuous for at least 40 cm. Careful filtering of the data for section end effects and/or other disturbances revealed an inclination change from steeply downward directions consistent with normal polarity at 217 m CSF-A, and below that they are steeply upward directed, consistent with reverse polarity.

Physical Properties

Physical property data were acquired on all cores of Hole U1605A using the Whole-Round Multisensor Logger (WRMSL) for wet-bulk density from gamma ray attenuation (GRA), magnetic susceptibility (MS), and *P*-wave velocity (PWL). Natural gamma radiation (NGR) was measured on all sections longer than 50 cm. NGR measurements were taken upon arrival in the laboratory, while WRMSL logging was done after equilibration to room temperature. X-ray imaging was completed on the archive halves of every core. Thermal conductivity was measured on the working-half section as one per core. The Section Half Multisensor Logger (SHMSL) was used to measure point MS and color reflectance using the L*, a*, b* color system, and the Section Half Imaging Logger (SHIL) was used to collect red-green-blue color space (RGB) of the sediments. Discrete measurements of *P*-wave velocities were measured on the working section halves for almost all cores, generally on one section per core, but measurements were taken at variable intervals to accommodate lithological variations. *P*-wave values at Site U1605 are strongly influenced by the presence of washed gravel and abundant clasts on the record. Samples for moisture and density (MAD) were limited to the intervals of compacted diamicton allowing assessment of wet-bulk density, dry-bulk density, grain density, and porosity for the sedimentary intervals of Site U1605. Variations in NGR, density, and MS measured on the WRMSL vary together with depth and presumably reflect major lithological changes through the poorly recovered succession. MAD density values range from 2.1 to 2.5 g/cm^3 and, although they are slightly higher by up to 0.5 g/cm^3, they generally correlate with the GRA bulk density measurements. Point MS values are more scattered than the MS values measured on the WRMSL, but otherwise exhibit similar trends. *P*-wave velocity caliper (PWC) measurements of the diamicton intervals range from ~1680 to ~2600 m/s and the diamicton intervals have an average porosity of 30%.

Geochemistry

Whole-round core samples were processed for interstitial water (IW), and headspace sampling (HS) void gas samples were measured at Site U1605; however, the frequency of these samples was limited by the availability of sediment. HS measurements show low concentrations of hydrocarbons in the upper 130 m CSF-A and increasing concentrations at depth, with a low yet consistent presence of ethane below 180 m CSF-A. While low recovery and sporadic sampling led to a discontinuous porewater record, the main findings from IW analysis include decreases in lithium and potassium with depth. A monotonic decrease in sulfate with depth to a minimum around 190 m CSF-A provides evidence for a sulfate–methane transition zone. IW iron, manganese and phosphate show elevated concentrations near the seafloor and sharp decreases to

low concentrations with depth. Increases in calcium and alkalinity in the upper ~100 m CSF-A are also observed. Elemental analysis of solid material revealed very low concentrations of carbon and nitrogen throughout the hole.

References

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