IODP Expedition 318: Wilkes Land Glacial History

Site U1360 Summary

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Site U1360 (WLSHE-09B) is located in the continental shelf off the Adélie Coast at 495 m water depth. The main objective at Site U1360 was to core across the regional unconformity WL-U3 to determine the timing and nature of the first arrival of the ice sheet to the Wilkes Land continental margin. Site U1360 lies at the eastern edge of the Adélie Bank and receives drainage from the East Antarctic Ice Sheet (EAIS) through the Wilkes Subglacial Basin. Glacier ice and the entrained debris draining through the basin and extending to the continental shelf would give the evidence for a large-scale ice sheet on Antarctica.

Regional unconformity WL-U3 is interpreted to record the first expansion of the EAIS across the shelf in this sector of the East Antarctic margin and to, therefore, separate pre-glacial strata below from glacial strata above (Eittreim et al., 1995; Escutia et al., 1997; De Santis et al., 2003). Drilling in Prydz Bay during ODP Leg 188 (O'Brien, Cooper, Richter et al., 2001), and results from DSDP 269 (Hayes and Frakes, 1975), ODP Leg 189 in the Tasman Gateway (Exon, Kennett, Malone, et al., 2001), and ODP Leg 182 Site 1128 in the Great Australian Bight (e.g., Mallinson et al., 2003), among others, led Escutia et al (2005) to postulate an Early Oligocene age (i.e., 33.5-30 Ma) for the development of the WL-U3 unconformity.

At Site U1360, unconformity WL-U3 is predicted to occur at ~165 mbsf (0.81s TWTT). Multichannel seismic reflection profiles crossing Site U1360 show gently dipping strata on the shelf truncated near the seafloor. This provided a unique opportunity to sample across the unconformity with very shallow penetration. The proximal record from Site U1360 was to complement the distal record of the first arrival of the EAIS to the Wilkes Land margin obtained at Site U1356.

Hole U1360A was drilled to a total depth of 70.8 meters below seafloor (mbsf) using the Rotary Core Barrel (RCB) system. Only 60 cm were recovered in the upper 14.3 mbsf and sediments are unconsolidated and moderately-to-strongly disturbed by drilling (Core U1360A-1R). Below 14.3 mbsf (Cores U1360A-2R to -6R), the sediments are consolidated and most recovered intervals are only slightly disturbed by drilling. Based on visual core descriptions and smear-slide analyses, Hole U1360A constitutes diamictons, mudstones, sandstones, and diamictites, which are placed into two lithostratigraphic units. Unit I consists of unconsolidated clast-rich sandy diamicton. The diamicton is slightly compacted, but soft, crudely stratified, and includes one lamina of clay-rich diatom ooze with a yellowish color at Interval U1360A-1R-1, 18-20 cm. A trace of diatoms is present in the matrix of the diamictite. Rare shell fragments are also present in this unit. Clast percentages are up to 25% and clasts are primarily composed of angular, indurated, olive green to olive brown mudstone fragments, 2-8 mm in size. Crystalline rock clasts, including basalt and gneiss, up to 7 cm in size, are also present and have sub-rounded and facetted shapes. The unconsolidated diamictons were probably deposited from floating ice, and most likely represent deposition from a floating glacier tongue or icebergs releasing debris over the site. The lamina of diatom ooze is indicative of a brief period of open marine conditions with high productivity and low terrigenous sedimentation rates.

The top of Unit II marks a sharp change in lithology and induration of the cores, from unconsolidated diamicton above, to carbonate-cemented claystone below. An Early Oligocene age is assigned to the interval below U1360A-3R-1, 8 cm, whereas no age assignment is possible for Core U1360A-2R. Five different lithofacies are recognized in a sequence from top to bottom in this unit: (1) olive green claystone with moderate bioturbation, (2) dark green claystone with dispersed clasts, (3) dark greenish gray sandy mudstone with dispersed clasts, (4) olive brown sandstone with dispersed clasts, and (5) gray clast-rich sandy diamictite. Overall, Unit II can be characterized as a fining upward sequence from diamictite at the base to claystone at the top. Bivalve shell fragments, some of which are pyritized, are common in the lower portion of Unit II. The lithofacies distribution is consistent with an ice-proximal to ice-distal glaciomarine depositional environment, similar to that described from the Oligocene and Miocene strata of the Victoria Land Basin, Ross Sea, Antarctica (Naish et al., 2001; Powell and Cooper, 2002). Five samples from Hole U1360A were prepared for XRD analysis of the clay fraction. A mixture of all the major clay mineral groups characterizes the clay mineral assemblages in these samples. The dominant clay-mineral components are smectite, illite, and chlorite, with a lesser contribution of kaolinite and pyrophyllite-talc. The cores assigned to the Early Oligocene have clay mineral assemblages similar to those reported from Lower Oligocene shelf strata around the Antarctic margin (e.g., Hambrey et al., 1991; Ehrmann et al., 2005). The abundance of illite and chlorite are consistent with a glacial-marine depositional setting for the claystone, mudstone, sandstone, and diamictite facies described within Lithostratigraphic Unit II. The relatively large contribution of talc, however, is not typical of Paleogene sediments on the Antarctic shelf and may reflect the weathering of a low-grade metamorphic facies, derived from a basic or ultrabasic igneous protolith, locally on the Wilkes Land margin or within the Wilkes subglacial basin.

Dinoflagellate cysts (dinocysts) and diatoms provide age-control for Hole U1360A. They suggest that Core U1360A-1R (0 to 0.54 mbsf) comprises an uppermost Pleistocene matrix, with intraclasts of Upper Eocene to Lower Oligocene material. An age could not be assigned to the strata between Samples U1360A-1R-CC and -3R-1, 8 cm (0.54 to 23.38 mbsf) due to poor recovery. Samples U1360A-3R-1, 8 cm to -6R-CC (23.38 to 53.78 mbsf) are of Early Oligocene (< 33.6 Ma) age.

Sediments within Core U1360A-1R (0 to 0.54 mbsf) comprise an uppermost Pleistocene matrix with intraclasts of Late Eocene to Early Oligocene age. Diatoms indicate that during the latest Pleistocene, the shelf at Hole U1360A was not subjected to year-round ice cover but was influenced by seasonal sea ice either directly, or indirectly. Combined microfossil analyses suggest the sedimentary interval below U1360A-3R-1, 8 cm (23.38 mbsf) is Early Oligocene (< 33.6 Ma) in age. Early Oligocene microfossils indicate a shallow-water shelf environment with low salinities and high nutrient levels, likely driven by seasonal sea ice. Sporomorphs may represent reworking from older strata and/or contemporaneous vegetation in the hinterland.

Two samples from Hole U1360A (Samples U1360A-4R-1, 15 cm and -4R-2, 72 cm) were reversely magnetized, consistent with an age of Chron C12r as predicted by the biostratigraphy.

The fining upward sequence from diamictites at the base (Core U1360A-6R) to claystones at the top (Cores U1360A-2R to -3R) is also documented in the general decrease in MS values from the bottom to the top of the hole. Variations in GRA density nicely reflect variations in lithology between clast-rich diamictite, sandy mudstone with dispersed clasts and claystone. Calculated porosity ranges from 49% to 17% and generally decreases with depth. Grain densities range from 2.62 to 3.13 g/cm^3. The slightly higher grain densities in Core U1360A-4R are most likely related to the occurrence of pyrite in the sediment (up to 8%).

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