IODP Expedition 318: Wilkes Land Glacial History

Site U1356 Summary

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Site U1356 (WLRIS-07A) is located at the transition between the continental rise and the abyssal plain at 4003 m water depth. The main objective at Site U1356 was to core across the regional unconformity WL-U3 to obtain the timing and nature of the first arrival of the ice sheet to the Wilkes Land continental margin in a distal setting.

Similarly to Site U1355, three regional unconformities reported from the Wilkes Land margin, WL-U3, -U4, and -U5 are imaged at Site U1356. Unconformity WL-U3, interpreted to separate pre-glacial strata below from glacial strata above, and presently inferred to have formed during the earliest Oligocene occurs at ~867 m (6.33 ms TWTT). Unconformities WL-U4 and WL-U5 are imaged at ~708 and 534 m (6.15 and 5.95 ms TWTT), respectively, based on assumed velocities. Coring across unconformities WL-U4 and WL-U5 was to provide a distal early Oligocene-(?)Pliocene record of glacial/interglacial (i.e., colder vs. warmer) and ice sheet and sea ice variability. Multichannel seismic reflection profiles crossing Site U1356 showed the site was to penetrate a thick sequence of stacked levee deposits developed between two deep-sea channels and above WL-U4. Based on their geometry and seismic facies associations, these levee deposits are interpreted to form when high-volumes of sediment were delivered to the continental shelf edge by a wet-based EAIS (Escutia et al., 2000). Reworking of turbidite deposits by bottom-water currents was also suspected based on the presence of wavy reflectors (Escutia et al., 2000, 2002; Donda et al., 2003). Drilling at Site U1356 was thus to examine the earlier stages of development of large sediment levees denoted by unconformity WL-U5 in addition to the drivers for this change. Below the levee deposits and closely coinciding with unconformity WL-U4, strata are characterized by horizontal and continuous reflectors of varied amplitude, which are interpreted to represent hemipelagic and distal turbidite and contourite sedimentation, based on comparisons with sediments recovered at DSDP Site 269 (Hayes and Frakes, 1975).

Hole U1356A was cored to 1006.4 meters below seafloor. The dominant lithofacies are moderately to strongly bioturbated claystone and calcareous claystone with a *Zoophycos* or *Nereites* ichnofacies. Subordinate lithofacies include laminated silty claystones, diamictites, mudstones and sandstones with dispersed to common clasts, and graded or cross-laminated siltstones and sandstones. These facies associations are interpreted to result from hemipelagic sedimentation with variable bottom current and gravity flow influence. Wavy sub-mm-thick black concretions observed below this depth are interpreted as a form of silica diagenesis. Carbonate cemented sandstones and conglomerates are also present below this depth.

The sedimentary section is divided into eleven lithostratigraphic units. Units I and II (0-278. 4 mbsf) are composed of diatom oozes and diatom-rich silty clays with dispersed gravel indicating hemipelagic sedimentation with ice rafting. Units III (278.40-459.4 mbsf), V (593.8-694.4 mbsf), and VII (723.5-782.7 mbsf), are characterized as repetitively interbedded light greenish gray bioturbated claystones and brown laminated claystones, with presence of cross-laminated siltstone and sandstone interbeds. These units are interpreted to indicate cyclical changes in bottom oxygenation, current strength, and fine-grained terrigenous sediment supply. Gravel-sized clasts are rare in these units and there is only minimal evidence for ice rafting from rare dispersed sand grains. Extensive interbeds of contorted diamictites and other gravel-bearing lithologies in Units IV (459.4-593.8 mbsf) and VI (694.4-723.5 mbsf) indicate a strong gravity flow influence. Units VIII (782.7-879.7 mbsf) and IX (879.7-895.5 mbsf) are comprised of mudstones with extensive contorted and convolute bedding. Unit X (895.5-948.8 mbsf) is composed of crudely stratified and graded sandstones. These units are affected by several types of mass transport, including submarine slides and slumps. Unit XI (948.8-1006.4 mbsf) is characterized by bioturbated claystones with subordinate stratified siltstone and sandstone, indicating hemipelagic sedimentation with minor bottom current and gravity flow influence.

Units IX, X, and XI (below ~880 mbsf) have a clay mineral assemblage dominated by smectite and kaolinite indicating chemical weathering under relatively warm and humid conditions. This clay mineral assemblage is distinctly different from that of the overlying units (above ~880 mbsf), where the dominant clay minerals are illite and chlorite, indicative of physical weathering in a glacially influenced environment.

Siliceous microfossils (diatoms and radiolarians), calcareous nannofossils, and organic walled dynoflagellate (dinocysts) are the primary source of microfossil-based age control for Hole U1356A. The different microfossil groups resolve the stratigraphy nearly exclusive of one another by depth. Diatoms provide a high-resolution stratigraphy for the uppermost Lower Miocene to the lowermost Pliocene drape (the upper 387 mbsf). Calcareous nannofossils and, to a lesser extent, dinocysts resolve the Lower Miocene and Oligocene interval between ~434.5 mbsf and ~875.12 mbsf). Dinocysts provide the only microfossil age-control for the lowermost Oligocene and the Eocene (~895.5 mbsf and

~995.32 mbsf). Radiolarians and planktonic foraminifera provide secondary age control, which is in agreement with the other fossil groups.

Diatoms and radiolarians suggest that the Pleistocene and all but the lowermost Pliocene (i.e., 0 to ~4.2 Ma) are missing from Hole U1356A, and that at least two other major hiatuses are centered around 4.6 mbsf and 28.38 mbsf; this indicates that much of the upper Upper Miocene is also missing. A break in sedimentation occurring within the lower Miocene is suggested by foraminifers and nannofossils, and appears to be associated with the WL-U5 reflector (~503 mbsf based on measured P-wave velocities at this site). The duration of this hiatus is at present uncertain because of major reworking (foraminifers, pyritized siliceous microfossils) and scant biostratigraphic data through this interval, but available evidence constrains this hiatus to the earliest Miocene. A relatively thick (~375 m) Oligocene sequence is constrained by magnetostratigraphy and partially on dinocyst and provisional nannofossil data. The lowermost Oligocene, the Upper Eocene and most of the Middle Eocene are missing in a long hiatus spanning 47.9 Ma to 33.6 Ma based on dinocyst evidence. This hiatus is associated with seismic reflector WL-U3. The oldest break in sedimentation occurs in Lower Eocene strata between Sample U1356A-100R-CC and -101R-CC (939.86 to 951.87 mbsf). Dinocyst stratigraphy indicates this hiatus spans from 52.2 Ma to 50.8 Ma.

There are three intervals with continuous enough recovery and sufficient biostratigraphic data to establish a correlation to the geomagnetic polarity time scale (GPTS). Cores U1356A-14R to U1356A-51R appear to correlate to polarity Chrons C5AAn to C5Cn.3n. A mid-Miocene hiatus could be placed just above Core U1356A-46R because the polarity stratigraphy from Cores U1356A-46R through U1356A-51R does not have a straightforward fit to Chrons 5Dn and below. Cores U1356A-68R to U1356A-92R correlate to polarity Chrons C7An to C12R. The lower-most normal polarity interval in Core U1356A-105R and the top part of U1356A-106R corresponds to Chron C24n.3n based on biostratigraphic evidence. Core U1356A-104R is dominantly reversed with a short normal interval correlating to C24n.2n also based on biostratigraphic data. The top of Core U1356A-104R and all of Core U1356A-103R record C24n.1n. While Core U1356A-102R is reversely magnetized and fits within Chron C23r and Core U1356A-101R could record the base of Chron 23n.2n. The correlation of Cores U1356A-100R and U1356A-99R is not straightforward because they are mostly reversely magnetized, while C23n.2n is normal. Since the transition recorded in Core U1356A-101R and correlation to C23n.2n fits with a constant sediment accumulation rate model extrapolating upwards from the C24n tie points, the hiatus is most likely positioned between U1356A-101R and U1356A-100R. The smallest gap would place the transition recorded in Core U1356A-99R at the base of C22n with Core U1356A-100R being C22r in age. This magnetostratigraphic interpretation matches the dynocist stratigraphy.

Carbonate contents for most of the section is below two weight percent and levels of organic carbon, sulfur, and nitrogen are below detection limits. Major and trace elements (SiO_2, Al_2O_3, TiO_2, K_2O, Na_2O, MgO, Fe_2O_3, P_2O_5, Sr, Ba, Sc, Co, V) show pronounced downcore variations, which can be summarized in three geochemical intervals: (1) an upper interval from 0 to 878 mbsf, where all elements show minor fluctuations, reflecting elemental association with biogenic and physically weathered terrigeneous phases; (2) a transitional interval from 878 to 920 mbsf, where all elemental concentrations show significant changes in their absolute values; and (3) a lower interval from 920 to 1000 mbsf, where most elements show characteristics of highly weathered terrigenous material.

Physical properties generally change at the identified lithostratigraphic boundaries in Site U1356. Velocity, density, and porosity data clearly reflect the positions of the main seismic reflectors WL-U5 and WL-U3. The relatively high grain density values (>3 g/cm³) starting at Lithostratigaphic Unit III (~ 275 mbsf) are most likely related to the occurrence of pyrite in the sediments (up to 20% according to the smear slide counts). Magnetic susceptibility data are exhibiting rhythmic changes especially visible in the cores with improved recovery starting at Core 318-U1356A-47R, but even better from Core 318-1356A-68R downward.

References

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