IODP Expedition 392: Agulhas Plateau Cretaceous Climate

Site U1581 Summary

Background and Objectives

Site U1581 (proposed Site TB-01A) is located on the deep, flat part of the Transkei Basin (35°40.8654′S, 29°39.0055′E) in 4591 m water depth. This area of the Transkei Basin shows a smooth bathymetry with water depths between 4000 and 4600 m, and no apparent dip can be recognized in the site's vicinity. The site is located on the crossing point of lines AWI-20050008 and AWI-20050014. The seismic data show that the Transkei Basin is characterised by the mounded structure of the Agulhas Drift, an elongate sediment drift about 220 m thick and rising about 200 m above the seafloor. This sequence shows a number of high amplitude internal reflections. Below the base reflector P of the Agulhas Drift, the reflection characteristics change towards lower reflectivity. The Agulhas Drift is underlain by the M Drift, a sediment drift formed during the Oligocene and Miocene (Schlüter and Uenzelmann-Neben, 2008). The M Drift shows a strike almost perpendicular to the Agulhas Drift, which is indicative of a strong change in the direction of the prevalent bottom current. Reflector M dominates the seismic image of the Oribi Drift in the middle of the sequence. Reflector E forms the base of the only up to 30 m thick seismic unit 2. Two reflectors K-T and B characterize the deepest seismic unit above rugged oceanic basement.

Site U1581 was chosen to recover Upper Cretaceous and Paleogene sedimentary record, as well as a partial Neogene sequence. This site was especially dedicated to target reflector B within the Cretaceous sequence. This reflector has been interpreted to represent black shales, and recovery of material from the reflector and above/below was intended to provide information on the formation of black shales in connection with ocean anoxia. Integration of seismic profiles with the drilling results will allow direct dating the observed seismic unconformities K-T, E, O, M, and P, and interpret their causes. Further objectives concern paleoenvironment and paleodepth of the Transkei Basin. At this site, critical intervals of ocean/climate transitions such as Mi-1 and Oi-1 glaciations, the Paleocene/Eocene Thermal Maximum (PETM), Cretaceous/Paleogene (K/Pg) boundary, Oceanic Anoxic Event (OAE) 2, and OAE 3 were expected to be documented in the sedimentary record.

Operations

After completing the 338 nmi voyage to proposed Site TB-01A (Site U1581), we arrived on site at 2345 h on 9 March 2022. All times are local ship time (UTC + 2 h). The thrusters were lowered, and the ship was switched to full dynamic positioning (DP) mode at 2357 h. The advanced piston corer/extended core barrel (APC/XCB) bottom-hole assembly (BHA) was assembled and we began tripping pipe to the seafloor. We attempted to shoot the first APC core from 4573.8 meters below sea level (mbsl); however, this resulted in no recovery (water core).

Two additional attempts from 4578.8 and 4583.8 mbsl also resulted in no recovery. Hole U1581A was successfully spudded at 2115 h on 10 March, recovering 6.88 m, and the seafloor was calculated at 4591.4 mbsl. APC coring continued to 207.2 m core depth below seafloor (CSF-A) (Core U1581A-24H). The advanced piston corer temperature (APCT-3) tool was run on Cores U1581A-4H, 7H, 10H, and 13H, with good data collected on all four. Pressure in the pipe increased while drilling the rathole of Core 24H. A mud sweep was pumped and the core barrel was pulled back to the surface while the crew continued to circulate and condition the hole with an additional two mud sweeps.

When the core barrel returned to the rig floor it had recovered 8.11 m (Core U1581A-25G; the designation for a core with an uncertain depth). A fray in the core line was also discovered and this was repaired. Cores 26H to 29H advanced to 233.8 m CSF-A. We then switched to the half-length advanced piston corer (HLAPC) system. Cores 30F to 38F advanced to 276.1 m CSF-A. We then switched to the XCB system and Cores 39X to 41X advanced to 300.5 m CSF-A; however, strong swells and resultant low recovery and poor core quality led to the termination of coring in Hole U1581A at 1800 h on 13 March. A total of 41 cores were taken in Hole U1581A over a 300.5 m interval with 90.9% recovery. Total time on Hole U1581A was 104.4 h (4.35 d).

The drill string was pulled out of the hole and pipe tripped back to the vessel, with the bit clearing the rig floor at 0825 h on 14 March. It was determined that a compassionate evacuation was needed for a crew member. An attempt was made to recover the acoustic positioning beacon; however, it was ultimately deemed lost. The vessel was switched from DP to cruise mode at 0945 h and the thrusters were up and secured at 1014 h, beginning the sea passage to Gqeberha (formerly known as Port Elizabeth). The vessel arrived at the edge of the Gqeberha harbor at approximately 0700 h on 15 March. Clearance for the departing crew member was received at 1300 h and they disembarked the vessel via launch at 1402 h. We then began the transit to Site U1581, arriving just before noon on 16 March. The BHA with a C-4 bit was made-up and tripped to 4499.7 meters below rig floor (mbrf) before a slip and cut of the drilling line. Hole U1581B was spudded at 0230 h on 17 March. A rotary core barrel (RCB) barrel with a center bit was used to drill ahead to 289 m CSF-A, with several mud sweeps during the drill down. The drill down portion of the hole averaged 46.2 m/h. The center bit was recovered and coring commenced with Core U1581B-2R at 1445 h on 17 March. Coring continued through 24 March with Core 74R at 997.1 m CSF-A, the final depth for Hole U1581B.

In preparation for downhole logging, the hole was swept with sepiolite mud to flush cuttings and the bit released at 1835 h on 24 March. The hole was further displaced with mud and the drill string was placed to 77.8 m CSF-A for downhole logging. The first downhole logging run was made with the Schlumberger Versatile Seismic Imager (VSI). The tool began its descent, but encountered a solid ledge at 222.4 m CSF-A. The tool was worked up and down for almost an hour, but was unsuccessful at passing the ledge. The decision was made to bring the tool back to surface and move the drill pipe down, to cover the ledge. The VSI cleared the rig floor and the drill pipe was run in to 408.5 m CSF-A. Due to the lack of daylight for another VSI run, a modified triple combo tool string was made up, with the DSI (Dipole Shear Sonic Imager) in place of the High-Resolution Laterolog Array (HRLA) unit. The tool string consisted of the Hostile Environment Natural Gamma Ray Sonde (HNGS), Hostile Environment Litho-Density Sonde (HLDS), DSI, and Magnetic Susceptibility Sonde (MSS).

Upon make-up, a problem was found with power to the lower portion of the tool string. This was replaced and the tool string was deployed. At 2606.8 mbrf depth (still within the water column), there was growing evidence of an electrical fault with tool. It was decided to bring the tool back to the surface, where the tool was repaired and redeployed. The triple combo tool reached 1300.0 mbrf but again showed an electrical fault, and the decision was made to terminate logging. The tool string was pulled out of the hole and the cause of the electrical fault was much later determined to be the conductors in the collector and pinched conductors in the logging head. The triple combo tools were disassembled and the drill string was tripped back to the vessel, clearing the seafloor at 0555 h and the rig floor at 1510 h on 26 March, ending Hole U1581B. A total of 73 cores were taken in Hole U1581B over a 708.1 m interval with 76% recovery. Total time on Hole U1581B was 243.12 h (10.13 d).

Principal Results

Lithostratigraphy

A ~994 m thick Pleistocene–Campanian sedimentary succession composed of calcareous and siliciclastic sediments was recovered at Site U1581. The upper part of the succession is relatively carbonate rich, whereas the lower part is dominantly siliciclastic in composition. The sedimentary sequence is subdivided into two lithostratigraphic units (I and II), both of which are further subdivided into two subunits: Ia, Ib, IIa, IIb.

Lithostratigraphic Unit I (0.0–390.05 m CSF-A) is a 390 m thick sequence of Pleistocene–Upper Paleocene biogenic ooze with variable amounts of sand, silt, and clay. The unit is divided into two subunits (Subunits Ia and Ib) on the basis of a higher concentration of siliciclastic material in Subunit Ib. Subunit Ia is 198.24 m thick and consists principally of greenish-gray, light yellowish-brown, and light brown clayey nannofossil ooze with biosilica, nannofossil ooze, grayish-green foraminifer ooze with sand, silt, and clay intervals. The basal contacts of thin sand intervals that overlie nannofossil oozes are typically sharp or erosive when well recovered. Carbonate content in Subunit Ia is highly variable, ranging between ~20 and 80 wt% within biogenic intervals and <1 wt% within siliciclastic intervals. Subunit Ib is 139 m thick in Hole U1581A and 101 m thick in Hole U1581B. It consists predominantly of siliciclastic sand, silt, and clay with occasional biogenic sediments, e.g., silty nannofossil ooze. Biogenic sediments are less common in Subunit Ib and occur as irregular, thin layers within thick packages of sand and silt. The siliciclastic sediments consist of medium- to fine-grained sand and silt layers that are massive or laminated and are occasionally normally graded. Carbonate content is generally low (<2 wt%) in Subunit 1b, except for in discrete decimeter-scale nannofossil-rich intervals where it can be as high as ~40 wt%. The contact between Units I and II at 390.05 m CSF-A is marked by a change in lithology from intercalated siliciclastic and calcareous sediments to dominantly siliciclastic sediments, as well as a decrease in average carbonate content.

Lithostratigraphic Unit II (395.70–993.97 m CSF-A) is a 582 m thick middle Paleocene to Campanian sequence of siliciclastic sediments consisting of sand, silt, and clay and sandstone, siltstone, and claystone. This unit is divided into two subunits (Subunit IIa and IIb) based on the degree of lithification (clay vs. claystone). Subunit IIa is ~90 m thick and consists of dark to very dark greenish-gray fine-grained sand and silt, clayey silt and very dark greenish-gray or black clay, clay with silt and minor greenish-gray to black silicified siltstone with glauconite. Bedding ranges from massive to laminated, with normal grading in some intervals. Well-preserved inoceramids (bivalves) and other shell fragments are observed macroscopically throughout the subunit. The contact between Subunit IIa and IIb is sharp, with Subunit IIb marked by a sharp decline in magnetic susceptibility, an increase in dry density, and a decrease in porosity. Subunit IIb is ~507 m thick and consists of dark to very dark greenish-gray siltstones, fine- to medium-grained sandstones, and very dark greenish-gray or black claystones. The sandy layers become less frequent downhole and are not present below ~791 m CSF-A. Mass movement is reflected by repeated fining upward sequences of sand to silt or silt with soft sediment deformation features such as convolute lamination or load casts. However, finer grain sizes in Unit II (clays and fine silts) suggest a more distal location with respect to the sediment source in comparison to Unit l.

Micropaleontology

The 994.02 m thick sedimentary succession recovered at Site U1581 consists of varying proportions of siliciclastic sediment and biogenic ooze, which contains calcareous nannofossils, foraminifers, dinocysts, radiolarians, and diatoms in varying abundance and preservation state. Within Lithostratigraphic Subunit Ia (0–198.24 m CSF-A; Pleistocene to late Miocene), calcareous nannofossils and foraminifers are generally abundant and moderately to well preserved throughout this subunit. Reworking of nannofossils is particularly prevalent in more siliciclastic-rich sediments. Diatoms and other siliceous microfossils (including radiolarians and silicoflagellates) are common to abundant and well preserved in the uppermost ~7 m of the sequence. Below this, moderately preserved diatoms are present in few to rare numbers down to ~110 m CSF-A, whereas radiolarians are common down to ~93 m CSF-A, and present in few numbers down to ~175 m CSF-A. Dinocysts are well preserved when present, but their abundance varies throughout Subunit Ia from present in the Pleistocene and Pliocene (0–101 m CSF-A) to sparse in the Miocene (121.13–198.24 m CSF-A).

Within Lithostratigraphic Subunit Ib (198.24–390.05 m CSF-A; late Miocene to mid-Paleocene), calcareous nannofossils are common to abundant and moderately preserved in many samples; however, they are occasionally rare or absent entirely in some intervals, particularly in coarser grained lithologies. Foraminifers are abundant but poorly to moderately preserved at the top of this subunit. Below ~240 m CSF-A, foraminifers are either absent or present in low numbers and poorly preserved. Siliceous microfossils are absent in this subunit. Poor preservation of dinocysts and miospores continues into the top of Lithostratigraphic Subunit IIb between 198.24 and 242.67 m CSF-A. Dinocysts and miospores are rare to common in the Oligocene (247.35–282.75 m CSF-A), absent in the Eocene (294.36–370.61 m CSF-A), and common to abundant in the Paleocene (378.61–395.70 m CSF-A).

Within Lithostratigraphic Unit II (395.70–994.02 m CSF-A; Paleocene–Campanian), calcareous nannofossil abundance and preservation varies significantly throughout the unit. Nannofossils are present in few to common numbers in only some Paleocene samples, with many samples completely barren. Nannofossils are generally present only in few numbers in the Cretaceous, but they are surprisingly well preserved, particularly between ~470 and 770 m CSF-A. Deeper than this, abundance decreases and preservation deteriorates, with the lowermost sediments devoid of nannofossils. Foraminifers are almost entirely absent in the >63 µm size fraction in Lithostratigraphic Unit II; however, small foraminifers <20 µm are observed in smear slides throughout the unit. Pyritized diatom fragments are common throughout much of this subunit. Although they are often fragmented, some samples contain nearly complete pyritized diatom valves. Preservation of dinocysts and miospores is moderate to good in Lithostratigraphic Unit II. Both are common to abundant throughout all samples investigated, and contain rich and diverse assemblages, which will provide ample opportunity for postcruise study of the terrestrial and marine paleoenvironmental evolution of the region.

The siliciclastic component of Site U1581 sediments includes coarse-grained units with sharp bases and normal grading that are interpreted as turbidites. As a result, an uncertain proportion of the microfossils found in the sediments of Site U1581 were likely transported from nearby shallower settings. Consequently, there is a significant component of reworked microfossils throughout the sedimentary succession at Site U1581, which complicates identification of the biohorizon tops of species. However, the biohorizons identified demonstrate a clear age progression, suggesting that transported sediments were deposited quasicontemporaneously.

Chronostratigraphy

Calcareous nannofossils, planktonic foraminifers, diatoms, dinocysts, and magnetostratigraphy provide age control for the Campanian to Pleistocene sediment sequence recovered at Site U1581. For the Campanian–Paleocene interval, nannofossils and dinocysts provide biostratigraphic age constraints that guided correlation of paleomagnetic reversals to the geomagnetic polarity timescale (GPTS) (Lithostratigraphic Unit II and lower Subunit Ib; 993.97 to 367.45 m CSF-A). The lowermost strata recovered at Site U1581 are dated to ~78.5 Ma by nannofossil biostratigraphy. Consistent normal polarity from the base of the hole at 993.97 m CSF-A up to 675.68 m CSF-A further constrains the age of the oldest sediment cored to <79.9 Ma, within Chron C33n. Biostratigraphic datums also constrain two paleomagnetic reversals at 675.68 and 657.83 m CSF-A to the C32r.2r/C33n and the C32n.2n/C32r.1r reversals, respectively. The Campanian/Maastrichtian boundary (72.17 Ma) is identified at ~532 m CSF-A using nannofossil biostratigraphy. Upsection, several additional nannofossil and dinocyst biohorizons constrain three paleomagnetic reversals at 557.50, 544.84, and 532.10 m CSF-A to the C32n.1r/C32n.2n, C32n.1n/C32n.1r, and C31r/C32n.1n reversals, respectively. Dinoflagellate biostratigraphy indicates an early Maastrichtian age for the strata between 531.50 and 467.19 m CSF-A. The stratigraphy across the Cretaceous/Paleogene boundary interval at ~466 m CSF-A interval is complex, with one or more possible hiatuses, significant reworking, and a complicated magnetic signal.

The Paleocene sequence recovered at Site U1581 also has a complex stratigraphy, with varying sedimentation rates and at least two hiatuses based on age constraints from dinocysts, nannofossils, and paleomagnetic reversals. The sequence from 466.45 to 444.20 m CSF-A has predominantly normal polarity and contains a number of dinocyst biohorizon bases, which are associated with the first phase following the K/Pg boundary. Nannofossils from this interval comprise a dominantly reworked Maastrichtian assemblage, but nannofossil markers for the base of the Paleocene are identified at 444.28 m CSF-A. The correlation of the reversal at 446.31 m CSF-A to the Chron C28r/C29n boundary is also consistent with the earliest Danian age indicated by dinocyst assemblages. Dinocyst biostratigraphy constrains the age of the interval between 439.24–435.50 m CSF-A to 64.0–63.4 Ma. The top of the Paleocene interval is dated to >58.80 Ma at 381.79 m CSF-A based on nannofossil biostratigraphy. There is a significant change in the assemblage at this stratigraphic level, indicating another hiatus and that much of the upper Paleocene and lower Eocene is missing at Site U1581.

The base of the Eocene section recovered at Site U1581 is placed at 367.45 m CSF-A and dated to ~50.65 Ma with nannofossil biostratigraphy. Nannofossil biostratigraphy indicates a late middle Eocene age at 321.01 m CSF-A, with low sedimentation rates (~0.4 cm/ky) calculated for the lowermost Eocene section. Nannofossil biostratigraphy further supports the presence of a hiatus or highly condensed interval at ~315 m CSF-A spanning the middle to upper Eocene. A lower Oligocene to lower Miocene sedimentary succession between 302.48–214.84 m CSF-A is constrained by 14 calcareous nannofossil and dinocyst biostratigraphic datums. Due to a poor paleomagnetic signal, no magnetic reversals were identified in this interval. Nannofossil biostratigraphy dates the ~215 m CSF-A to 20.98 Ma (early Miocene). Above this, there are two hiatuses or highly condensed intervals within the Miocene succession spanning ~21 to 7 Ma.

The age-depth model for the uppermost Miocene to Pleistocene sedimentary succession at Site U1581 is constrained by 20 diatom, dinocyst, and calcareous nannofossil biostratigraphic datums, and 8 magnetic reversals. Nannofossil biostratigraphy dates the base of this interval to ~7 Ma at 185.54 m CSF-A and the top of this interval to 0.29 Ma at 1.35 m CSF-A. Sedimentation rates are interpreted to be relatively continuous through the Plio-Pleistocene interval, although the frequent occurrence of turbidites likely means that sedimentation rates vary at a finer scale.

Paleomagnetism

Paleomagnetic measurements were undertaken on archive section halves from Holes U1581A and U1581B and on 110 discrete samples from both holes. Paleomagnetic experiments included alternating field (AF) demagnetization, anisotropy of magnetic susceptibility (AMS), and isothermal remanent magnetization (IRM) acquisition. These experiments were performed to constrain magnetic polarity and the magnetic mineralogy of sedimentary units from Site U1581. Paleomagnetic results are of variable quality, and magnetic polarity could only be determined from ~50% of the cores recovered from Hole U1581A and ~65% from Hole U1581B. From cores with clear magnetic polarity, nineteen reversals were identified and correlated to chrons within the GPTS from GTS2020 (Gradstein et al. 2020; Ogg 2020). These include Chrons C1n through C2Ar (Pleistocene–Pliocene) in Hole U1581A and Chrons C19r through C33n (Middle Eocene–Campanian) in Hole U1581B. Rock magnetic results indicate that the magnetic mineralogy comprises both ferri- and antiferromagnetic minerals. There is no observable trend in magnetic mineralogy with depth or between sedimentary units. Measurements of AMS indicate that the majority of samples from Site U1581 possess a typical oblate sedimentary fabric; however, samples from the basal ~75 m of Lithostratigraphic Subunit IIb possess a prolate fabric, likely indicating a tectonic imprint.

Geochemistry

The geochemistry program at Site U1581 was designed to characterize the composition of bulk sediment and interstitial water (IW) and report on the presence and abundance of volatile hydrocarbons for routine safety monitoring. Methane values range from 0.7 to 1458 ppmv. Hydrocarbons with longer chain lengths up to n-hexane (C6) were detected from 490.52 to 990.12 m CSF-A (bottom of Hole U1581B). The consistent presence of headspace gas up to hexane in the lower part of Hole U1581B is consistent with a thermogenic origin of the hydrocarbons. Notably, ethane/methane (C2/C1) ratios are markedly elevated between 490.52 and 655.22 m CSF-A, with a maximum at 610 m CSF-A.

IW samples were analyzed in Holes U1581A and U1581B down to 978.88 m CSF-A), and pore water was extractable in all but the lowermost sample in Core 74R (990.02 m CSF-A). Alkalinity values increase from roughly 3.4 mM in the shallowest sample at 2.96 m CSF-A to 10.02 mM at 74.81 m CSF-A. Alkalinity values then decrease to a value of 1.43 mM at 277.5 m CSF-A and remain relatively constant between 0.831 and 2.335 mM below this depth. pH values range from ~7.5 to 8.0 down to ~625 m CSF-A, and ammonium values follow a trend quite similar to alkalinity in all Hole U1581A samples, with a maximum value of approximately 1161 µM at ~100 m CSF-A, decreasing to ~280 µM at ~256 m CSF-A. Ammonium then steadily increases to the bottom of the hole to values of ~1 mM.

Of the major anions, sulfate decreases from a value of ~28 mM at 2.96 m CSF-A to ~14 mM at ~138 m CSF-A. Sulfate then increases slightly to a value of 18.06 mM at 358.31 m CSF-A, before decreasing again to 3.75 mM at 722.91 m CSF-A. Chloride decreases downhole from 574 mM in the uppermost section to values as low as 455.48 mM in the deepest part of the section. Sodium shows a marked increase in variability below ~200 m CSF-A with concentrations ranging between ~440 and 530 mM. Magnesium concentrations decrease downhole from 50.95 mM to 6.68 mM at the base of the hole. Calcium decreases from a concentration of 10.32 mM at 2.96 m CSF-A to 6.94 mM at 93.81 m CSF-A, before increasing to a maximum concentration of 20.95 mM at 377.71 m CSF-A. Below ~400 m, Ca concentrations decrease to ~6 mM at the base of the section. K concentrations decrease from a maximum of 11.39 mM at 19.37 m CSF-A to 1.2 mM at 600.70 m CSF-A. Below this depth, K concentrations remain stable between ~1 and 2 mM.

In total, 201 sediment samples were analyzed for bulk carbon and nitrogen analyses at Site U1581. Total carbon and carbonate weight percentages range from 0 to 10.01 wt% and 0 to 83.36 wt%, respectively, which is consistent with the deposition of pelagic biogenic oozes and lithological observations. More variability and overall the highest carbonate content is observed in biogenic oozes down to 198 m CSF-A. Below 200 m CSF-A, inorganic carbon and carbonate content typically decrease to below 10 wt%, with averages of 0.97 wt% and 8.11 wt%, respectively. The main carbonate mineral phase is likely calcite for the predominant part of the upper biogenic ooze lithologies; however, in the more siliciclastic sediments below 200 m CSF-A, the carbonate content may include other carbonate minerals, including siderite and dolomite. Despite these uncertainties, carbonate carbon persists in selected samples to the bottom of the analyzed sedimentary section (~993 m CSF-A). The average total organic carbon content is 0.46 ± 0.31 wt% with minimum and maximum concentrations of 0 wt% and 1.69 wt%, respectively. Average total organic carbon is slightly elevated to 0.52 wt% below 200 m CSF-A to the base of the recovered section at Site U1581.

Physical Properties

Standard measurements of physical properties were made on cores from Holes U1581A and U1581B using the Whole-Round Multisensor Logger (WRMSL), Section Half Multisensor Logger (SHMSL), and the Natural Gamma Radiation Logger (NGRL) track instruments. Discrete measurements were also made for moisture and density (MAD) analysis, thermal conductivity, and *P*-wave velocities on the *P*-wave caliper system.

In Hole U1581A, core disturbance was common in cores collected with the APC, HLAPC, and XCB systems, affecting the continuous track measurements of physical properties for cores. Discrete sampling for thermal conductivity and MAD analyses avoided core disturbance wherever readily identifiable. Many of the clay-rich lithologies at Site U1581 expanded in volume upon recovery, likely altering some physical properties. In Hole U1581B, the trends in physical properties show a continuation of observations recorded in Hole U1581A. Average natural gamma ray (NGR) levels and deconvolved uranium (U), thorium (Th), and potassium (K) concentrations are higher at Site U1581 compared to the two previous sites on the Agulhas Plateau, reflecting lower carbonate content and higher clay content in the Transkei Basin. Values for *P*-wave velocity, thermal conductivity, and bulk density all increase downcore through the biogenic oozes of Lithostratigraphic Subunit Ia in the upper 198.24 m CSF-A. At the contact between Lithostratigraphic Subunits Ia and Ib (~198.24 m CSF-A), a sharp ~0.2–0.3 g/cm^3 increase in bulk density occurs where a hiatus is indicated by biostratigraphic analysis. Finer-scale changes in physical properties at Site U1581, such as in NGR and magnetic susceptibility (MS), are associated with decimeter-scale nannofossil ooze/chalk beds, which are likely turbiditic in origin. A major increase in MS to ~400 instrument units (IU) occurs in the clayey silts and silty clays of Lithostratigraphic Subunit IIa (395.70–486.07 m CSF-A) and corresponds with the Cretaceous/Paleogene (K/Pg) boundary interval. The grain density of claystones in Lithostratigraphic Subunit IIb (486.07–994.02 m CSF-A) is high (~2.75 to ~2.85 g/cm^3) and likely relates to the presence of authigenic minerals such as pyrite and siderite. *P*-wave velocity at Site U1581 increases downcore relatively linearly from ~1650 m/s at the seafloor to ~2200 m/s at the base of Lithostratigraphic Unit II (994.02 m CSF-A).

Downhole Measurements

Standard downhole measurements at Site U1581 in the Transkei Basin included formation temperature measurements in Hole U1581A. Due to electrical connection problems during wireline logging of Hole U1581B, only NGR wireline logging data were collected between ~80 and 220 m WMSF using the Enhanced Digital Telemetry Cartridge (EDTC) device run at the top of the triple combo tool string.

The logging data provide downhole NGR data across the poorly recovered interval at the base of Pliocene-Pleistocene drift deposits. These data allow for detailed correlation between Cores U1581A-10H to 26H and downhole logging data. A cyclic pattern in the downhole NGR profile is characteristic for alternating sand and clay-rich turbiditic deposits.

Borehole formation temperatures were measured using the APCT-3 tool during piston coring of four cores in Hole U1581A (Cores U1581A-4H, 35.4 m CSF-A; 7H, 54.4 m CSF-A; 10H, 92.4 m CSF-A; and 13H, 120.9 m CSF-A). The temperature measurements were of good quality, displaying characteristic thermal cooling curves. The equilibrium borehole temperatures were calculated using the TP-Fit software (Heesemann et al., 2006): 2.83 ± 0.002°C, 4.13 ± 0.002°C, 5.43 ± 0.011°C and 6.10 ± 0.033°C. A geothermal gradient of ~37.0°C/km and a heat flow of ~47.3 mW/m^2 were calculated using Bullard's method. These preliminary results are generally consistent with nearby prior measurements for the Transkei Basin published in the global heat flow database by Fuchs et al. (2021), but require further postcruise analysis and uncertainty estimation.

References

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